POWER

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PHILIP W. SWAIN, *Managing Editor*

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MORE JOBS

• *POWER* HERE PRESENTS the essence of a plan, fitted to the letter and spirit of NIRA, to increase employment and wages through self-liquidating expenditures.

• THE BASIC IDEA originated with a power-equipment manufacturer. It is offered here for three reasons: 1. Analysis shows it to be in line with sound public policy; 2. It directly concerns the field of many of our readers; 3. It cannot be put into effect without the active cooperation of engineers.

• THIS PLAN will be outlined in more detail in October *Power;* only the high spots will be touched here.

• VERY BRIEFLY, the program will put into immediate motion an important, but now neglected, provision of the National Industrial Recovery Act. Only engineers can, at the start, appreciate its great possibilities. They must point the way.

• NIRA, Title II, Sections 202 and 203, directs the President, through Secretary Ickes, to prepare a program of public works, including the *repair and improvement of public buildings.* It permits him to finance such federal jobs from public funds.

• STATES AND CITIES may be granted up to 30 per cent of the cost of material and labor for projects of this nature, plus a loan of the remaining 70 per cent.

• HERE IS AN INVITATION and an opportunity directly in the power field. We refer particularly to the mechanical equipment of public buildings: boilers, stokers, prime movers, heating and ventilating systems, elevators, refrigeration, lighting equipment, piping, plumbing. Every engineer knows that many investments in this field will pay out in a few years.

• IN THE LONG RUN they won't cost the U.S. a nickel, and right now they will employ much labor in the manufacturing and installation of equipment, as well as professional services in survey, layout and supervision. They will not increase productive capacity. Labor cost will be a very large part of the total expenditure. The jobs, all indoors, can move ahead in cold weather, when highway work lags.

• BUT THIS POINT must be brought home: Only engineers are competent to determine which power-service improvements will pay. Without their cooperation in a national survey, intelligent operation of this plan is impossible.

• OCTOBER *POWER* will present a nontechnical statement of the plan. It will make clear to officials of Federal, State and City governments what the plan is, what it will do for the public and where the engineer fits in. Meanwhile, think it over.

Selling the Weather

• Weather has always been a commodity. The Eskimo swaps fish for sealskin boots to make summer for his feet. His more civilized brother demands and gets more—June air in August and December.

On a recent hot day nineteen advertisers in a single New York newspaper offered weather for sale as part of their services: 1 hotel, 2 restaurants, 1 railway train, 1 department store, 13 movie houses and 1 theater. More and more consumers are demanding year-round comfort. The certain results are increasing orders for air conditioning units and more jobs for engineers who know how to operate them.

Johnson is Right

• Some sensitive souls protest the "ballyhoo" of NRA. They think the blue "bird" ought to be more cold and dignified. But by what ethereal process do they imagine that the people of a whole nation may be marshalled to save their collective hides? What big war has been won without organized enthusiasm plastered onto the framework of armament, men and training?

Is it ballyhoo to sound a fire alarm when there is a fire, or to yell for a rope when you're drowning? Is it ballyhoo to pep a trained football team to make a touch-down? This is the day of much ado, but not about nothing. Only a false alarm is ballyhoo. Johnson is right!

The Lower Limit

• How small a power plant will pay its keep? The answer, of course, is that "it all depends"—depends on load factor, power-steam load balance, fuel price, labor set-up and the competing purchased-power rate schedule. In one place it may pay to install 100 kw. In another it may be cheaper to buy, though the load be 10,000.

Still it is interesting to see how small a plant may pay in special circumstances. England displays a paying plant of 20-kw. in two turbine units—complete exhaust utilization and no extra men. Other examples would be interesting and might give penny-shaving hints to larger plants.

Power Pioneering

• Power progress never stops. In this number alone are three fine examples of radical ideas that have grown commercial roots. "Radio City" installs steam-jet refrigeration for luxurious air conditioning. Under-water flames for process evaporation establish themselves in industry. The all-welded diesel steps forward, pointing the way to lower weight and cost in other reciprocating power units.

These developments are not merely interesting; they are *important*. And they are just a taste of what is coming in the next ten years.

More Coal Dollars

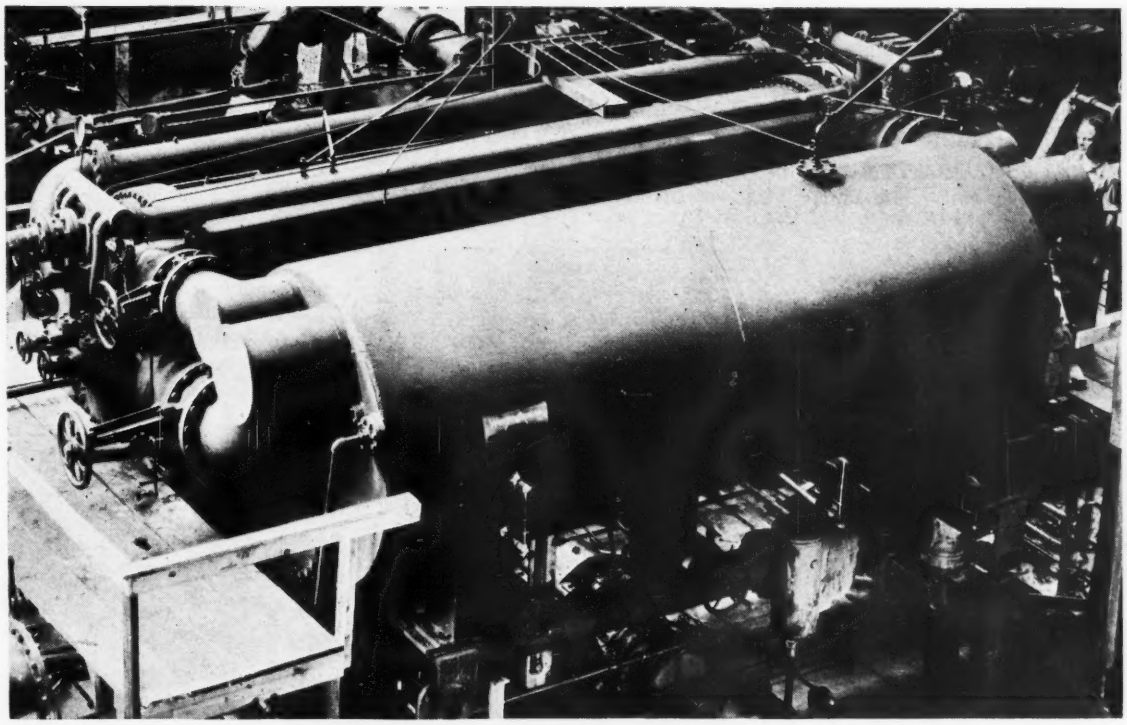
• Any worth-while code for the coal industry must make coal cost more. *Power* favors a living wage for miners and operators, and hence, by implication, a higher cost (within reason) for the fuel its readers must buy.

This may not sound like the embattled "standing up for our rights" attitude an industry paper is traditionally supposed to assume, but we believe it to be simple common sense as well as good ethics. First the ethics: The starvation of miners is too high a price to pay for cheap coal, particularly now when square-shooting citizens are moving forward in a united front. Next the common sense: A moderate general coal price rise will not penalize one manufacturer in his competition with others. And he, with them, will get the back kick of miners' enhanced purchasing power to carry a fraction of a cent increase in power cost.

But within this rising coal market, *Power* will continue to urge its readers to buy the best fuel bargains and squeeze from each pound the last economic B.t.u.

POWER Stands for

1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases
5. Better Use of By-product Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application
8. Prevention of Smoke, Within Reason



Steam-jet refrigerating equipment of 300-ton capacity on the test floor

RADIO CITY AIR CONDITIONING includes some STEAM-JET refrigeration

By ANDRE MERLE
Air Conditioning Engineer, Clyde R. Place

Through the air-conditioning equipment of Rockefeller Center, over 810,000 gal. of chilled water and 72,000,000 cu.ft. of conditioned air will be circulated an hour, the equipment for this purpose costing over $1,500,000. The air-conditioning system in the French Building, the most recent of this group, is here described

"ROCKEFELLER CENTER," popularly known as Radio City, is located in mid-town New York. Aside from its features of sheer size and architecture it houses mechanical equipment representing the most modern engineering design and practice. It contains the largest and most advanced air-conditioning systems yet installed. The total refrigeration to date is well in the neighborhood of 3,000 tons. Of this amount, 600 tons consists of steam-jet equipment and 2,400 tons of centrifugal machinery, electrically operated.

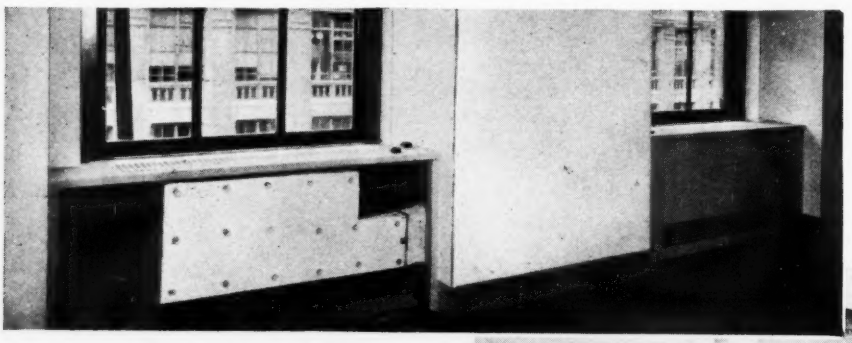
Situated at the southwest corner of Fifth Avenue at Forty-Ninth Street is "La Maison Française," the latest unit of Rockefeller Center to be completed. It houses leading French commercial, financial and industrial organizations. Six stories in height, with a basement and sub-basement, its frontage is 75 ft. on Fifth Avenue and 200 ft. on Forty-Ninth St. The upper floors have been assigned to offices; the basement floor and part of the ground floor will consist of store space. A feature will be the salons for permanent and periodic exhibition of many lines of deluxe merchandise never before displayed outside the borders of France.

Better to control the conditioning of the building and maintain it economically, three conditioning zones were established; 1—Basement floor system, 2—Ground floor system, 3—Second to sixth floors system. Installation of one system would have called for special structural conditions. All of the equipment, such as fans, dehumidifiers, pumps, control panels and the 300-ton steam-jet equipment are installed in a space 40 ft. deep; 70 ft. wide and 14 ft. high. Of special importance is the fact that the floor-space requirements for the steam-jet equipment are well within those required for centrifugal or reciprocating watercooling machinery.

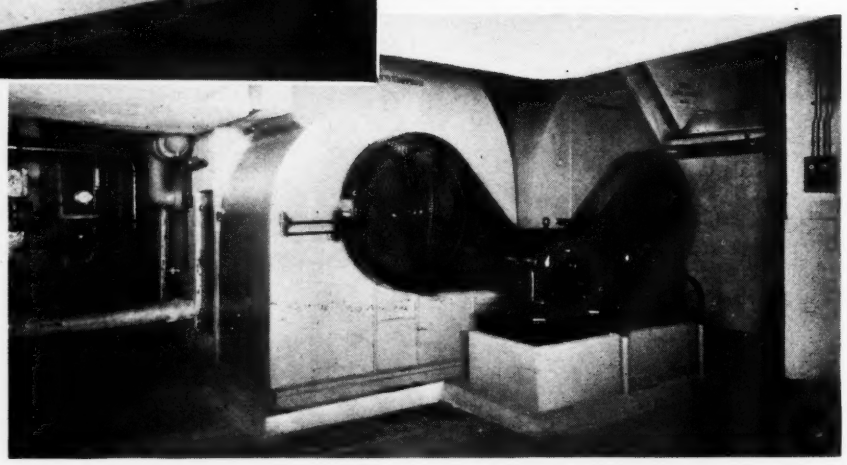
"Cooling with Steam" is today a commercial reality. The installations at Rockefeller Center were the first ever installed for air cooling. Of primary importance for air conditioning is its ability to produce, economically, relatively high-temperature chilled water. The unit can produce from 1 to 300 tons of refrigeration at practically a uniform cost per ton. The entire cycle of operation is extremely safe and free from moving parts. Steam-jet equipment is composed of the following principal parts: 1—Thermo-compressors (Boosters), 2—Flash chamber (Evaporator), 3—Condensers, 4—Auxiliaries (Inter and after condensers, air cooler and condenser condensate pump), 5—Refrigerant (Water), 6—Steam at 100 to 135 lb. pressure, and 7—Induced draft cooling tower.

Refrigeration effect is produced by the four thermo compressors within the condenser. A high vacuum is maintained within the flash tank so that a portion of the warmed return water immediately flashes or evaporates into steam, and is thus chilled. The temperature and quantity of chilled water is automatically controlled and depends solely upon the vacuum maintained within the flash tank. At a vacuum of 29.75 in. Hg., 45 deg. chilled water is produced. There are two 16-in. and two 20-in. diameter boosters capable of producing a total cooling effect of 300 tons. One is fully automatic, while the other three are arranged for hand control. A thermostat in the flash tank will automatically close the main steam valve should the chilled water approach the freezing temperature. The flash tank is approximately 6 ft. in diameter and 16 ft. long, constructed of welded structural plates. Baffles and other water-diffiusion devices are installed within the tank. The condensers consist of a special design shell-and-tube arrangement, of 4-ft. 9-in. diameter, 16 ft. 3 in. long. The vacuum normally carried is 28 in. in the primary condensers and 22 in. in the secondary. The inter and after condensers, along with the air cooling apparatus are standard for this type of work.

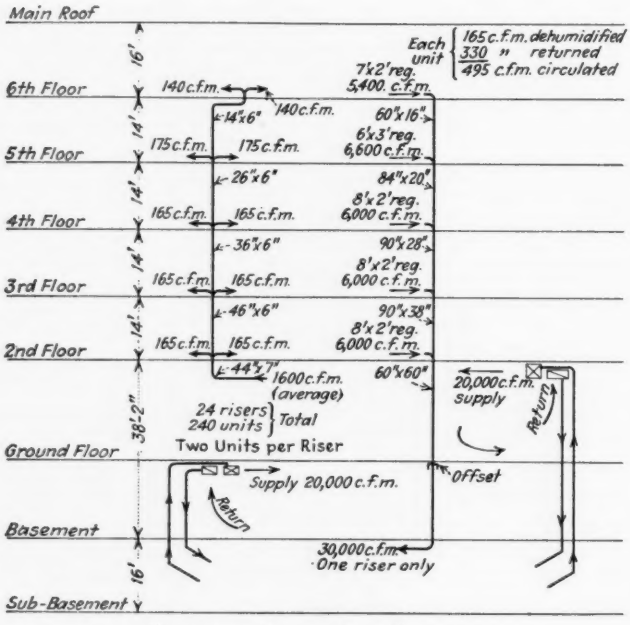
A special design of horizontal liquid level control was installed on the flash tank. During normal operation, less than 4 per cent of the total chilled water circulated will be evaporated. This water, along with the condensed steam, is removed by a condensate pump. The total operating weight of the steam-jet equipment is 40,000 lb.



Left—Conditioned air is admitted at each window through the insulated duct in front of fin-type radiators



One of the air-conditioning units. The air washer is behind the fan



Duct riser diagram for offices

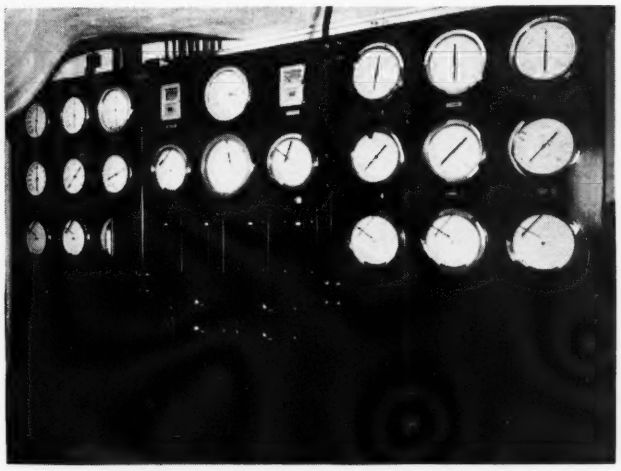
Condenser Water Cooling Tower

The heat extracted by the condenser water is equivalent to that absorbed by the chilled water, plus the heat in the propelling steam. A series of tests fixed the condenser water requirements at 1,500 g.p.m., 5 g.p.m. per ton with a cooling range of 20 deg. with water entering the cooling tower at 102 deg. and leaving at 82 deg. The towers were designed to produce 55-deg. water when the outside wet bulb approaches 50 deg. and 72-deg. water at 65 deg. wet bulb. Make-up water is furnished automatically by a pump in the sub-basement and the roof

house tank. The completed cooling tower measures 20x19x22 ft. high and is housed within the pent house or roof level of the building. The tower is of California red fir with the water pan lined with sheet lead. Four 2-stage, disk-type quiet fan units are installed at the top. The operating weight of the tower is 134,000 lb.; the tower proper weighs 87,000 lb. and the water 47,000 lb. Extra-depth eliminators insure freedom from mists or water spray. Should an emergency arise, city water can be utilized direct until the towers or pumps are placed in operation.

Pumps of Special Design

Extreme care was exercised in the selection, design and installation of all pumps. Centrifugal-type, double-suction, horizontal, split-shell, high-efficiency, quiet-operating pumps are installed. The chilled water and condenser condensate pumps are of standard condensate design. The chilled water pump withdraws air-free water at 45 deg. from the flash tank, under a vacuum of 29.75 in. Hg. The condenser condensate pumps operate against a vacuum of from 22 to 28 in. Hg. and handle about 30 g.p.m. of water at 102 deg. temperature.



Central gage board for steam-jet refrigeration, air-conditioning and heating equipment

Chilled water is delivered under automatic control to the dehumidifier spray pumps. These pumps, in turn, utilize all or a part of this chilled water, mixing it with recirculated spray water and thus controlling and tempering the dehumidified air. The chilled water, after use, flows by gravity to a concrete storage tank under the sub-basement floor. From this tank, the suction leg of the steam-jet flash tank draws the water for chilling.

Water Treated For Corrosion Prevention

The water recirculated in the various dehumidifiers and cooling towers will be treated to retard corrosion. A special type of hydrogen ion (pH) recorder controller regulates the application of a corrosion neutralizer, and pH will be maintained between 7.5 and 9.5. The neutralizer will also remove all traces of offensive odors so noticeable in recirculated waters of an air washer or cooling tower.

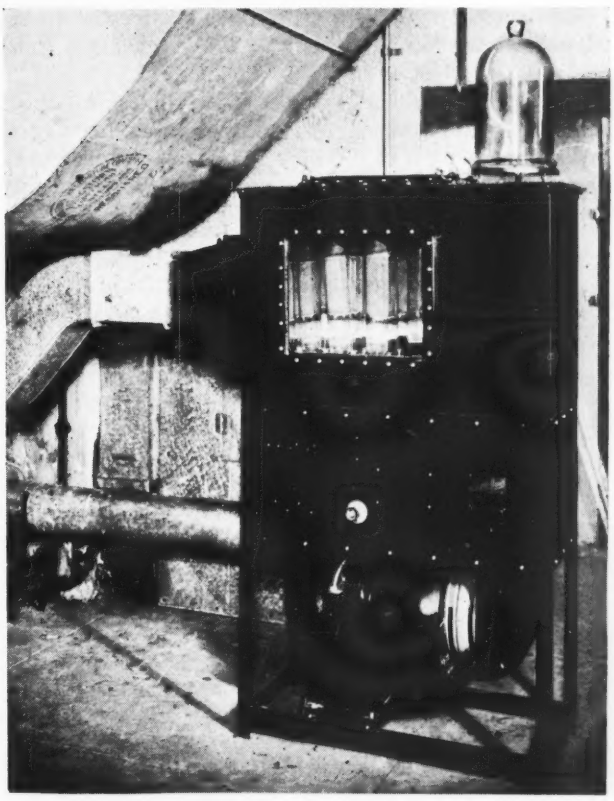
A decidedly novel system of air distribution consisting of window cabinets is installed under each window throughout the office section. The basis of the system is the noiseless introduction of relatively small quantities of 50- to 55-deg. dehumidified air at from 1,400 to 1,500 ft. per min. Active uniform air circulation is created ejector fashion, and from two to three times the original quantity of air is thus circulated. The pick-up air tempers the dehumidified air and an average circulation of approximately 65-deg. air results. Individual control of the cabinets is readily accomplished by turning a small knob until the desired conditions are obtained. The dehumidified air is supplied to the window cabinets through vertical ducts in the outer walls, extending from the first to sixth floors inclusive. The exhaust or return air duct, in the elevator corridor, is the only duct within the office space. All other ducts are in the outside wall.

During the winter period, the air is tempered by means of Arco blast heaters located in the sub-basement apparatus. Between the outer wall and the window cabinets conventional direct concealed radiation is installed for normal heating.

The store-air distribution duct work is located over the show cases. Combination stream-lined grilles admit the conditioned air noiselessly at a speed of well over 1,800 ft. per min. without drafts or chill spots. The return ducts are also located over the show windows adjacent to the supply ducts. With this arrangement, merchandise can be distributed at will, without affecting the air distribution system.

Automatic Temperature and Humidity Control

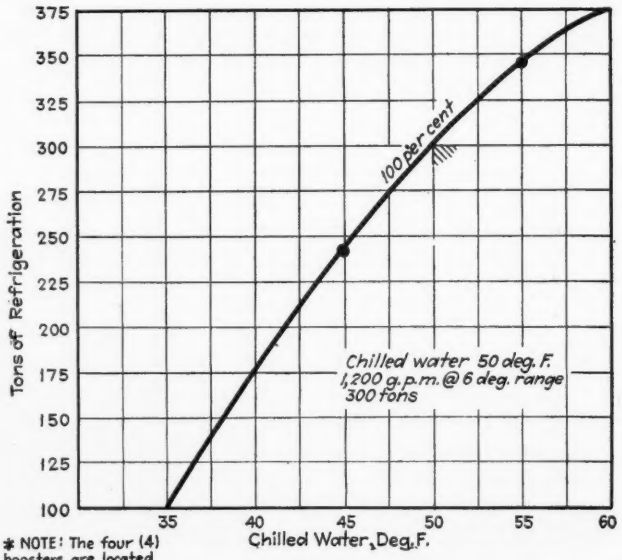
A relatively new wet bulb type system of control has been installed, similar to the dew point type more commonly employed. The wet bulb system maintains a positive control of both the dry and wet bulb temperatures within the conditioned zone. It not only regulates the temperature and mixture of the dehumidified air, but through a system of primary and secondary thermostats, controls both the rapidity and degree of temperature and humidity change. This type of control automatically



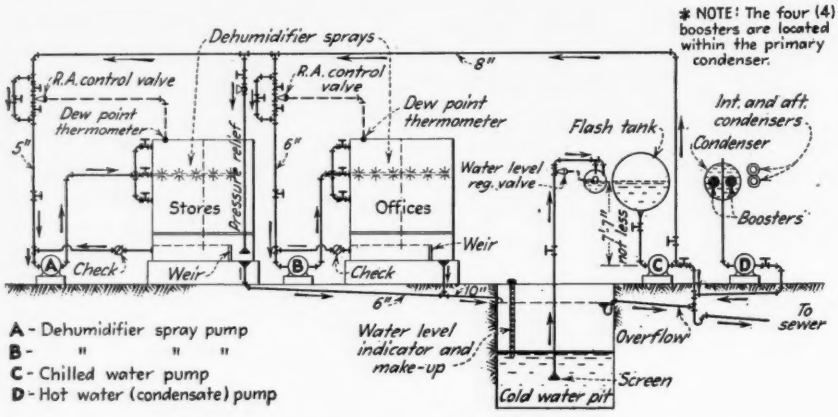
One of three units for ionizing the conditioned air

admits the required amount of fresh air, insures the correct air pressure, excludes infiltration and provides a complete change of air on an average cycle of six minutes. Instruments record the wet- and dry-bulb air temperatures, chilled and condenser water temperatures. Gages indicate the various pump pressures and vacua in the steam equipment. The quantity of steam used and gallons of chilled water circulated are also recorded.

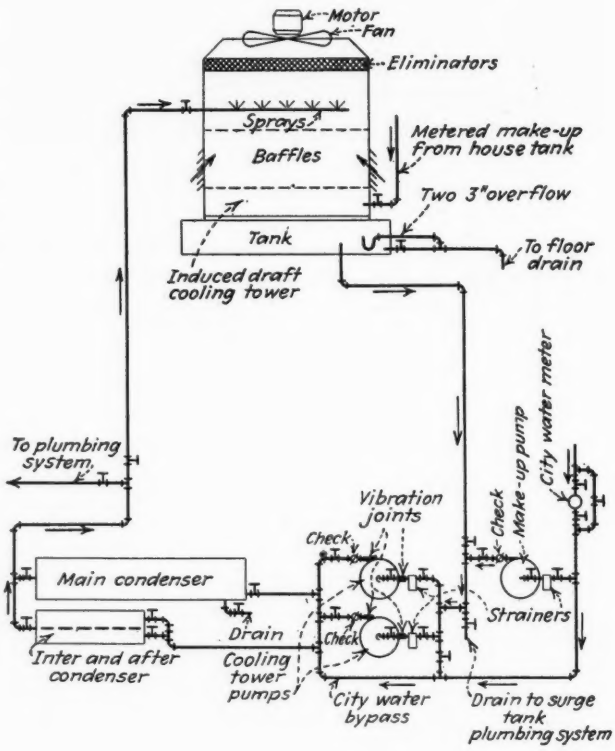
All of the air circulated is thoroughly washed, filtered and ionized at all times. The air washing feature consists of a new-design combination dehumidifier and air washer with three banks of sprays and a bank of flooding nozzles. The combination dehumidifier was made large enough to produce comfortable conditions by means of evaporative cooling, thus producing economical refrigeration. The air filtering is accomplished by a double set of Re-Nu type air filters, constructed of a double thickness of fabricated steel wool made into pads 20x20x2



Characteristic curve of 300-ton steam-vacuum refrigerating unit



Typical chilled water-flow diagram



Schematic water piping for steam-jet condenser and cooling tower

in. and coated with an odorless viscous fluid. In order that conditioned air be "alive" and free from objectionable odors, it is ionized. This is accomplished by means of three automatic Radi-Ion machines, connected to the various air-conditioning systems. These machines function automatically.

John D. Rockefeller, Jr., as sponsor for the financing of this large undertaking, formed the Rockefeller Center Corporation, with Col. Arthur Woods, as president to direct it. The air-conditioning apparatus was furnished by the American Blower Company, the steam-jet equipment by Westinghouse Electric & Manufacturing Company. All engineering design, specifications and inspections were performed by Clyde R. Place and staff.

TABLE NO. 1
INSIDE CONDITIONS WITH VARIOUS OUTDOOR WET AND DRY BULB TEMPERATURES,—DEG. F.

Outdoor Conditions		Inside Conditions	
Dry Bulb	Wet Bulb	Dry Bulb	Per Cent Relative Humidity*
95	75	80	50
90	73½	78	53
85	72½	76	57
80	71	75	60
75	68	73	63
70	60 approx.	72	67

*Constant Indoor "Dew Point Temperatures."

TABLE NO. 2
COMPARISON OF HORSEPOWER REQUIREMENTS

Motors	Steam Systems	Compressor Systems
Air Conditioning Fans	50 hp.	50 hp.
Cooling Tower Fans	60 hp.	40 hp.
Air Compressor for Control	3 hp.	3 hp.
Radi-Ion Machines	1 hp.	1 hp.
Condenser Water Pumps	65 hp.	35 hp.
Chilled Water Pumps	30 hp.	50 hp.
Dehumidifier Spray Pumps	35 hp.	35 hp.
Refrigeration Machine	.....	350 hp.
Condensate Pump	2 hp.	.....
Total	246 hp.	564 hp.

HIGH-PRESSURE EVAPORATORS

Some Operating Tips

By HARRY M. SPRING
Milford, N. J.

DUE to increasing use of high-pressure evaporators in both central station and industrial service, a few operating pointers supplementary to manufacturers' instructions may be beneficial to some readers. Use of the evaporator in an industrial power plant is especially advantageous because it allows a closed feed-water cycle. Lowered boiler maintenance and minimum feed-water treatment result.

Thermal expansion and contraction of the heating coils take place on sudden temperature changes when blowing down and refilling. This serves to shed surface scale from the coils. The scale drops to the bottom of the shell and passes out with the blowdown.

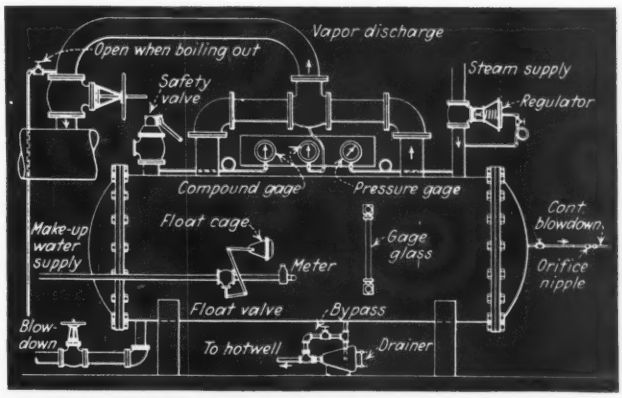
During operating hours, periodic tests on the evaporator should be made to determine concentration and proper time intervals for blowing down. Maximum allowable concentration will, of course, vary with the type of evaporator, pretreatment of make-up water and such other factors as may be present in the individual case.

Good results in the removal of scum and other surface impurities from the water will be had with the use of a surface-continuous blowdown. This should be tapped into the shell at the average water level. In one installation the surface blowdown line consisted of a $\frac{1}{2}$-in. pipe having a $\frac{1}{8}$-in. orifice. This line may discharge into any waste vacuum line having a higher vacuum than that which may occur in the evaporator. Suitable discharge points for this line may include condenser tailwater piping, sumpwell pump suction, generator air cooler tailwater piping, etc.

A high-pressure, single-effect evaporator should be equipped with at least three pressure gages. One gage should be calibrated higher than the maximum steam pressure to the coil and should be connected at the supply end of this coil. Two compound pressure gages should be connected, one tapped into the vapor outlet from the shell and the other tapped directly into the top of the shell or the safety valve nipple.

Common practice for the past few years has been to install an internal purifier within the evaporator to remove any solids in the entrained water. The pressure differential shown by the readings of the two compound gages will show the pressure drop across this purifier. In spite of all such precautions carry-over by foaming is still occasionally experienced. Much of this has been eliminated by installing a rectangular baffle plate of sheet steel in a horizontal position midway between the water level and the purifier bottom. This plate has an area of from 50 to 75 per cent of the water surface area.

If, after some time, a pressure differential of greater than 10 per cent of the maximum operating shell pressure is shown, it will be necessary to clean out the purifier. This may be done by removal from the shell



and scraping by hand, but this is a long tedious job in a large evaporator and is usually unnecessary.

It has been found that most of the solids which encrust the purifier surfaces are soluble in hot water, so an easy method of cleaning the purifier is: The float valve on the water supply is blocked open, filling the evaporator with water, and the float is left blocked in this position. The valves on the vapor discharge and blowdown lines are closed. Steam is then passed through the coils and the water in the shell is allowed to boil about fifteen minutes. During this boiling out a $1\frac{1}{4}$-in. line from the evaporator side of the vapor discharge gate is opened to the sump. As the water boils out of this line, carrying dissolved impurities to the sump, fresh water is constantly admitted, keeping the purifier under water. The shell should then be drained, refilled and boiled out a second time. After this is done it may be drained, refilled to the correct operating level and placed in service.

Many are the methods that are used in blowing down, but one very effective one is given. Steam supply and vapor discharge valves are closed. The make-up water line is shut off and high-pressure steam is admitted to the shell by a special $\frac{3}{4}$-in. line tapped in to the top. As soon as the shell pressure builds up to about 50 per cent of the safety valve setting, the blowdown valves are opened. An indication that the shell is empty will be a sudden drop in the positive pressure reading of the two compound gages. This is caused by a loss of the water seal on the blowdown line and the sudden release of steam through it. A small quantity of water is then admitted to the shell to flush it out, and this is then blown out. The evaporator is then filled with water to the correct operating level and placed in service in the usual manner. When filling the shell, water should be admitted by a by-pass of large diameter around the meter and float valve in order to cause maximum coil cooling and contraction.

An evaporator should be drained and refilled in this manner after standing idle for over eight hours. If this is not done, the action of the water on the scale will have raised the concentration to such a value as to cause probable carry-over through foaming.

CLEAN THE AIR—

AND SAVE THE MACHINE

Reductions as high as 80 per cent in maintenance costs have been shown by experience to be possible through installation of air filters on compressors and internal combustion engines, as compared to operation with unfiltered air

AIR compressors and internal combustion engines handle tremendous volumes of air. Even when this air contains a small percentage of dirt, a volume detrimental to machine operation is taken into the cylinders. Operation of these classes of equipment with and without air filters has demonstrated the economic importance of supplying clean air to them.

In an internal-combustion engine, the chief objection to dirty air is contamination of lubricating oil and wear of pistons, cylinders, and valves and increased carbon deposits. It is estimated that 85 to 95 per cent of the so-called carbon deposited in internal-combustion engines is dust saturated with oil and baked into a hard mass. These objections also apply to air-compressor operation. In addition, the air supplied by the compressor is contaminated with dirt, which makes it more difficult to supply clean, compressed air.

One would not consider throwing a handful of dirt into the cylinder of an air compressor or internal-combustion engine, yet this is about what is being done on many machines that are operated without air filters. For example, consider a 2,000-c.f.m. air compressor and assume it operates at full capacity on an average of 10 hr. per day, six days per week. In one week there would pass into the compressor 7,200,000 cu.ft. of air.

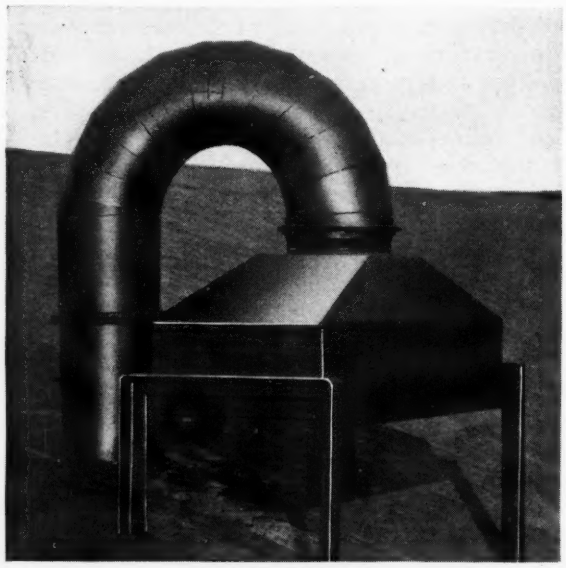
According to authorities, air in industrial districts contains from 1 to 4 grains of dirt per 1,000 cu.ft. If the air contained 1 grain only per 1,000 cu.ft., 7,200 grains of dirt would pass into the compressor in one week's operation. Assuming the higher figure of 4 grains per cu.ft., 28,800 grains of dirt would be carried into the compressor during a week's operation.

As 7,000 grains equal 1 lb. from 1 to over 4 lb. of dirt would be taken into the compressor. If the operator of a compressor were to see a very small part of this actually tossed into the compressor cylinder, it would be something to get excited about.

In the interest of effective lubrication and low maintenance cost, it is highly desirable that the air supply be properly filtered. It is of little use to take every precaution to prevent lubricating oil from being contaminated before it is put into the machine, if no attention is given to the oil after it goes into use. Within the last few years automobile manufacturers have come to realize this important fact and are spending millions of dollars to equip the engines they put into their cars with air filters. If it is necessary to filter the air for an automobile that has an average operating life of not more than 250 8-hr. days of service, then it is of far greater importance to protect compressors and engines that are expected to give years of reliable and efficient operation.

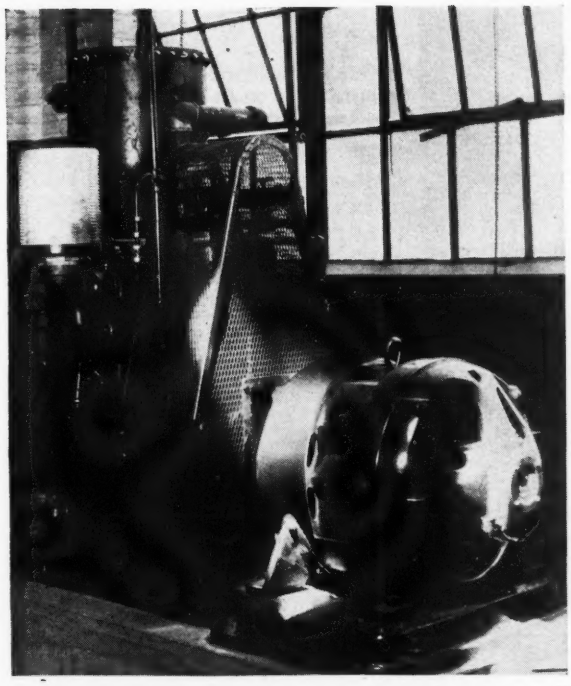
For lubrication to be effective, it must form an unbroken film. This it cannot do if contaminated with foreign matter such as that carried by air into cylinders of compressors and engines. Frequently much of the dirt carried in air is of an abrasive character. If allowed to get into the cylinders, it mixes with the lubricating oil and causes rapid wear of piston rings, cylinder walls, valves and other parts.

How serious the wear may be because of dirty air is shown by a test made by the United States War Department. Two new gasoline engines, as nearly alike as it is possible to build them, were subjected to 240 hr. of identical operation, one being equipped with an air filter and the other operated without.



Hanging type outdoor, dry-type filter on the intake of a 2,500-c.f.m. air compressor is located on the plant roof

Three of 12 dry-type filters installed outdoors on the intakes of air compressors



Dry-type filter installed directly on the intake of a small air compressor

After this period of operation in severe dust conditions, careful measurements were made of the wear on the pistons, cylinders and piston rings and an analysis made of the carbon deposits. The unprotected engine showed nine times the amount of wear on the cylinders, four times the wear on the pistons and ten times the wear on the piston rings. The carbon deposits in the engine run without an air filter contained five times more dirt than found in the engine operated on filtered air. The unprotected engine was practically worn out, but the other was in good condition. The excessive wear on the unprotected engine occurred in spite of the fact that it was supplied with 40 per cent more oil than the one with the air filter.

Dirt in the air also causes increased carbon deposits in the cylinders and on the piston rings and valves, which combined with increased wear reduces efficiency and causes increased maintenance costs and outage time for repairs. For example, the valves on a 5,000-c.f.m. compressor operating in a railroad shop required cleaning every two weeks when the air intake was unprotected by a filter. After an air filter was installed on the compressor, the only attention required by the valves was to wipe them off once every six months.

Investigations made of maintenance and repair costs of internal-combustion engines and air compressors with and without air filters show that the filters will pay large dividends on their costs. Comparing two 5-yr. periods for 10 engines operating on natural gas showed an annual saving in maintenance of $631, or a 65.5 per cent return on the cost of the filters. On a large air-compressor installation, the annual saving in maintenance was $2,228, a reduction in this cost of 79.5 per cent and a return of 69.9 per cent on the investment in air filters. On another installation of two small compressors, an annual saving was made in maintenance equal to 62.8 per cent on the cost of the air filter.

Of course, the value of air filters on any installation depends upon local conditions. If operation is continuous for 24 hr. per day where the air is very dirty, air filters may more than pay for themselves in a single year by the saving in maintenance and lubrication costs, increased efficiency and reduced outage time. On the other hand if operation is intermittent and the air is fairly clean, the saving in operating cost made by the installation of an air filter may be small. However, experience with the protection of many machines has shown that it pays to protect.

The condition of the air leaving the compressor is another consideration that cannot be overlooked in the operation of air compressors and will be considered in a future article.

It is desirable that an air compressor be supplied with sufficient lubrication only to lubricate the cylinders and valves properly. Any excess contaminates the air, increases carbon deposits, making it more difficult to clean the air and adds to the explosion hazards in the discharge pipe and receiver. If the amount of oil used is to be kept to a minimum for effective lubrication, then dirt must be kept out of the compressor by filtering the air supply.

For cleaning air to air compressors and internal-combustion engines several types of filters are available, some of them capable of removing over 99 per cent of the dirt from the air passing through them. The design and arrangement will vary with the size of the unit protected, the dirt in the air and other conditions. One type that has come into wide general use operates on the adhesive-impingement principle. Dust-laden air is drawn through a series of viscous-coated-metal baffles, called the filter media, which break the air current up into fine streams, causing the dust to be impinged against the many surfaces of the baffles.

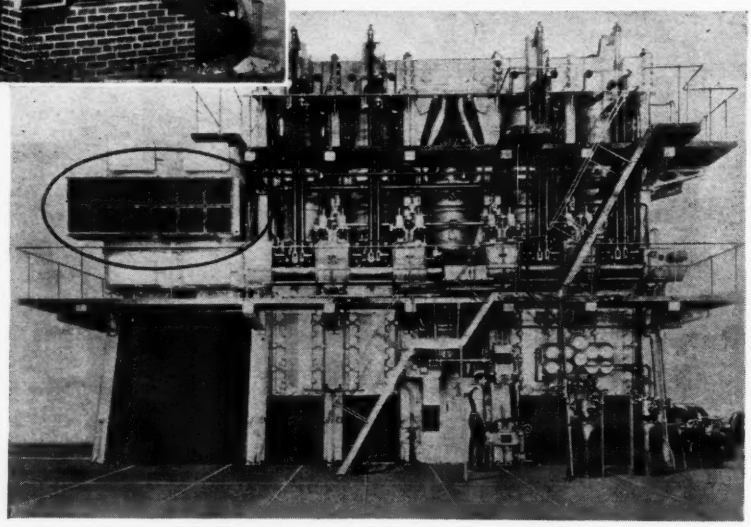
The filter media in this type consists of expanded metal or crimped wire depending upon the kind of air cleaning required and the manufacturer. In one type of these filters, the filter media is glass wool, which is packed in square frames to form a unit of convenient size for handling. These units are combined in assemblies to provide the desired capacity.

Those types using a viscous-coated-metal filter media are generally constructed so that they can be cleaned by washing in a solution after which they are recharged with the viscous solution. Glass-wool type filters are not cleaned when dirty, but are discarded and replaced with new ones.

Several dry-type filters are available. These are made in various forms according to their capacity and type of installation. As used on air compressors and internal combustion engines these filters usually consist of an assembly of pockets formed of wire or wire mesh over which is placed a special felt or filter cloth through which the air passes. These are cleaned by passing air through them in an opposite direction to the normal air flow or by using a vacuum cleaner on the outside. In some larger-size dry-type air filters the filter cloth is supported in the form of bags, from which dust is removed mechanically.

Some of the small-size filters are of the centrifugal type that remove the dirt by whirling the air around the inside wall of a circular intake chamber. Combinations of the adhesive-impingement and centrifugal principles are also used. In these the air is given a primary cleaning by centrifugal action, the dirt being collected in an oil pool. After being subjected to this action, the air then passes through an adhesive impingement filter for the final cleaning.

Outdoor adhesive-impingement-type filter installation on air intakes to four 1,250-hp. diesel engines in a municipal plant



Twelve adhesive-impingement type air-filter units installed on the air intake of a large diesel engine

Another type of filter consists of perforated aluminum plates with a fireproof film on their surfaces. The plates are arranged in frames so that the air in passing through the holes on one plate impinges upon the metal between the perforations in the following plate. In this way the dirt is projected against the film and thus retained, while the air changes its direction to flow through the orifices in the plate. By this process the air is cleaned as it passes through ten successive plates in the standard-type filter.

For very large installations, air washers may be used. In these the air is first passed through atomized sprays of water. Leaving the spray chamber, the air passes between corrugated metal sheets kept flooded with a film of water, so that the dirt which has been wetted by the spray is thrown against the sheets and washed to the settling basin below. Any unabsorbed moisture in the air leaving the washer is removed between dry corrugated plates.

Air-filter applications to air compressor and internal-combustion engines are made in various forms some of which are shown in the photographs. These filter installations are typical, but they do not cover the whole range of applications, as they may be installed in any form required to meet local conditions.

Information for the preparation of this article was supplied by the American Air Filter Co., Inc.; Staynew Filter Corp.; Coppus Engineering Corp.; American Blower Corp.; The Dust Recovery & Conveying Co.; Owens-Illinois Glass Co.; W. W. Sly Manufacturing Co.; Buffalo Forge Co.; Holly Pneumatic Systems, Inc.; The Northern Blower Co.; Burt Air Filter Corp.; Michiana Products Corp.; A. C. Spark Plug Co.

COOLING TOWERS vs. CITY WATER

By GUSTAV J. BISCHOF

Consulting Engineer, Cooling Tower Co., Inc.

ALMOST all industries use water for cooling purposes. Too few managers analyze the several uses of water and discriminate between the unrecoverable portion and that which is only heated and could be re-used if properly cooled. Deducting the loss by evaporation and windage, 90 to 95 per cent of warm water when re-circulated over a cooling tower is recoverable for re-use. Such conservation of cooling water mounts to surprisingly large savings over a number of years, and yields large returns at small expense when subjected to even a superficial study.

Contrary to general opinion, the first cost and upkeep of water-cooling equipment is small compared to city water costs over a number of years. As with other equipment, comparison between the present expense (cost of purchased water) and the yearly charges for the operation, upkeep and financing of the contemplated water-cooling equipment is the only sound basis on which to decide the economy of installation. To stress economy rather than technology of water-cooling apparatus, the graphical analyses of the application of atmospheric cooling towers using the above basis of comparison are shown in Figs. 1 to 3.

Yearly charges for city water and the yearly charges

against the atmospheric cooling tower are plotted as ordinates forming two curves for different-sized installations in the fields of refrigeration, condensing steam-turbines and internal-combustion engines. The vertical difference between the two curves represents the annual saving accruing from the use of an atmospheric tower. All yearly totals are based on an operation of 15-hr. per day for 300 days a year or 4,500 hr. of operation per year. The cost of water was taken as $1 per 1,000 cu.ft., a fair average cost for city water in the eastern United States.

Charges against the cooling tower include items of pumping cost for the circulating water, sinking-fund deposit to cover depreciation, interest on investment, upkeep and cost of city make-up water to replace that evaporated or lost by windage. The investment figure includes a suitably sized redwood atmospheric cooling tower and basin, and the necessary supporting grillage, all erected on the roof of a building, together with the cost of a pump and motor of corresponding capacity. Fixed charges are based on 6 per cent interest, 15-year

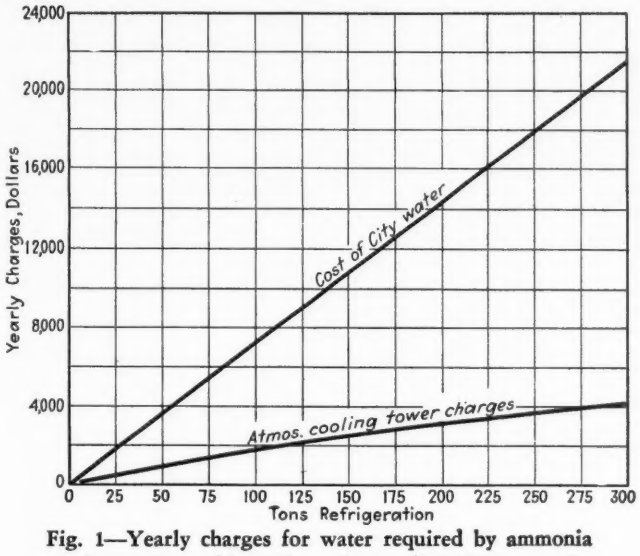


Fig. 1—Yearly charges for water required by ammonia condensers in refrigeration plants of various capacity

life and 3 per cent upkeep charges. Pumping charges are figured on the comparatively high industrial rate of 3 cents a kw.-hr. for electric energy. Labor charges are omitted, as the cooling tower requires no further attention or expenditure than that allowed for under the above 3 per cent upkeep charge.

Economies for various-sized refrigeration installations are shown in Fig. 1. Water circulation for cooling ammonia condensers is taken at 3 g.p.m. per ton of refrigeration (10-deg. cooling range). As the size of the cooling tower is determined almost entirely by the tons of refrigeration which it serves, the figures will not change materially for other circulations and cooling ranges.

A critical survey of water costs will often disclose much waste of cooling water that could be economically re-used by providing means for cooling it. The annual cost of cooling towers for this purpose is here compared with cost of city water

Fig. 2 deals with cooling water economies for condensing the steam of high-vacuum steam turbines. An exhaust vacuum of 28 in. Hg. is assumed with 940 B.t.u. dissipated per lb. of steam condensed. A turbine steam rate of 20 lb. per kw.-hr. is used as a conservative figure for average-size units. A properly proportioned surface condenser is assumed, with a difference between outlet water and the corresponding vacuum temperature of 8 deg. F. On the other hand, city water charges are based on securing city water at 63 deg. F.

Fig. 3 deals with the economies of cooling water used for jacket cooling in diesel engines. City water consumption is based on a 50-deg. F. rise in the cooling water, and the cooling tower circulation is computed on a 40-deg. F. rise. The general figure of 3,400 B.t.u. per b. hp. per hr. absorbed by the cooling water is used.

The present study, of necessity, confines itself to three representative applications. Furthermore, the results obtained vary as the individual conditions differ from those used in the study. However, the outline of investigation followed is general, and the writer hopes that by this graphical representation, the economic advantages of water cooling will be brought more clearly to the attention of those responsible for plant operation economies.

Fig. 2—Yearly charges for steam turbine condenser cooling water

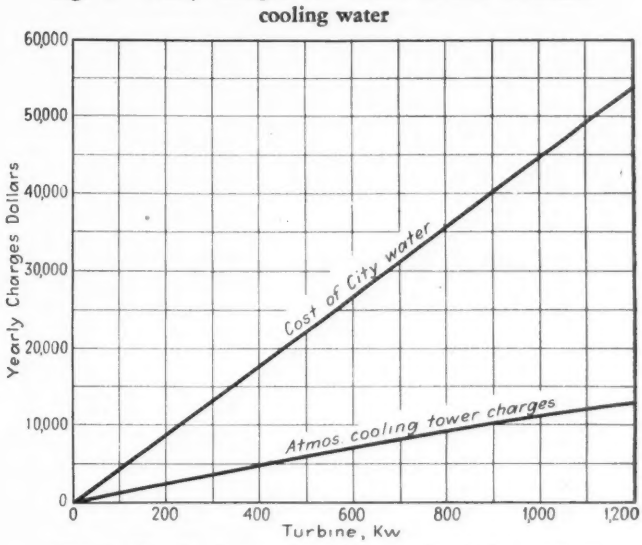
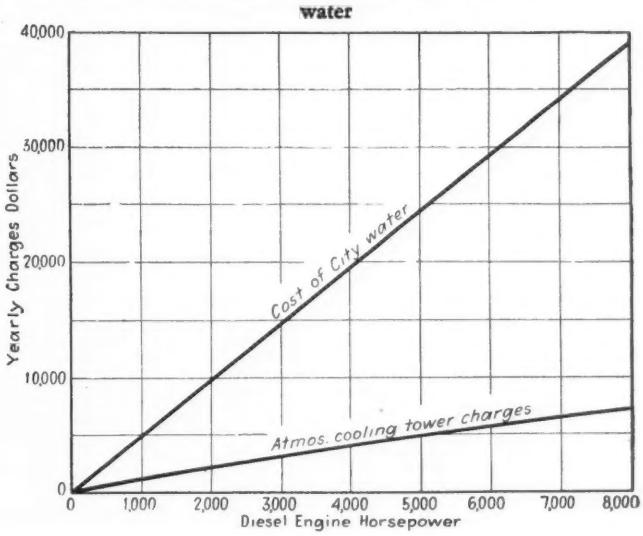
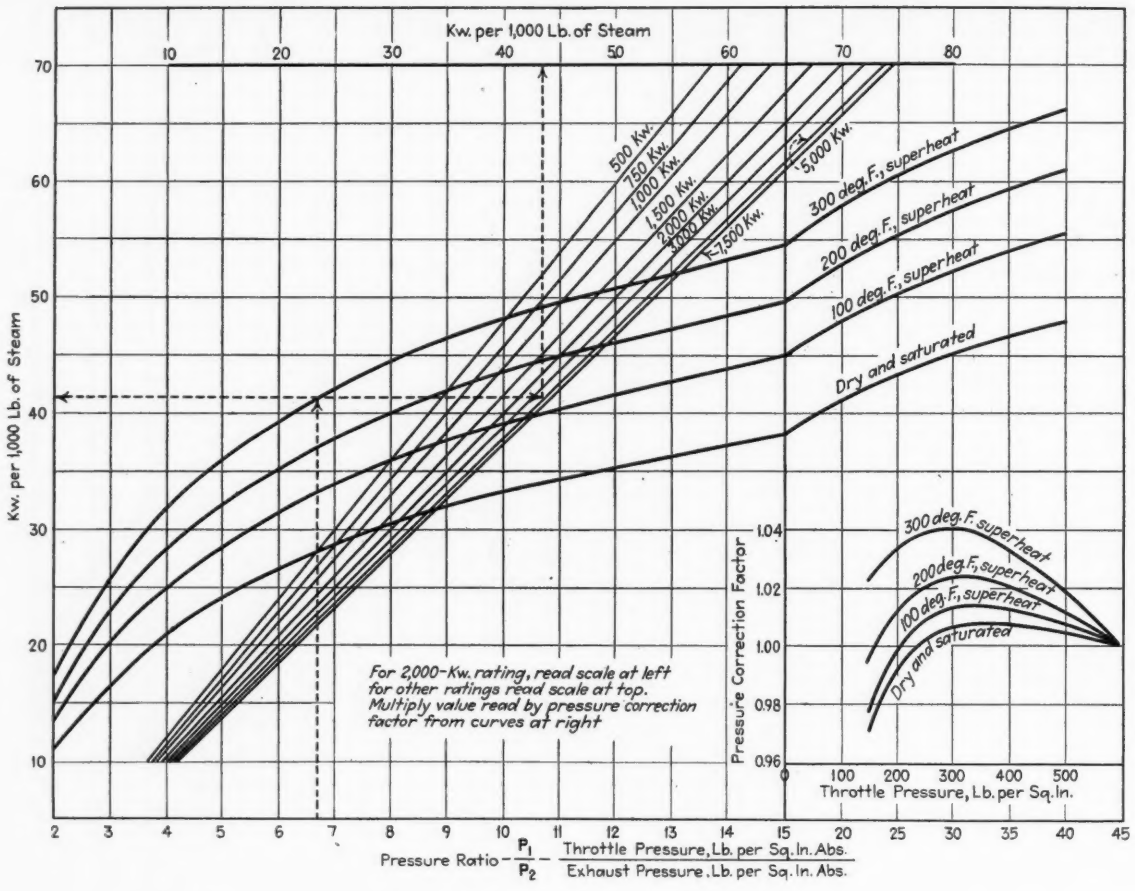


Fig. 3—Yearly charges for diesel engine jacket cooling water




Kw. per 1,000 Lb. of Steam
Kw. per 1,000 Lb. of Steam
500 Kw.
750 Kw.
1,000 Kw.
1,500 Kw.
2,000 Kw.
3,000 Kw.
5,000 Kw.
7,500 Kw.
300 deg. F., superheat
200 deg. F., superheat
100 deg. F., superheat
Dry and saturated
For 2,000-Kw. rating, read scale at left
for other ratings read scale at top.
Multiply value read by pressure correction
factor from curves at right
Pressure Correction Factor
300 deg. F. superheat
200 deg. F., superheat
100 deg. F., superheat
Dry and saturated
Throttle Pressure, Lb. per Sq. In.
Pressure Ratio — P1/P2 — Throttle Pressure, Lb. per Sq. In. Abs. / Exhaust Pressure, Lb. per Sq. In. Abs.

HOW MUCH
POWER FROM PROCESS STEAM

By NORRIS D. GOVE

Design Engineer, Westinghouse Electric & Mfg. Co.

Engineers often have to answer the question, "What steam conditions are necessary to generate a required amount of byproduct power from factory demands for process steam?" The curves in this article will help solve this problem

WHEN a non-condensing prime mover is used as a reducing valve between a high-pressure steam supply and a lower-pressure steam demand, the power generated is almost wholly a byproduct. The steam in its passage through the turbine loses only a comparatively small proportion of its heat, and the heat remainng is just as good for heating purposes as when the steam is generated at the lower pressure or generated at higher pressure and throttled to the lower. The B.t.u. rate of a turbine operating this way, no matter what its internal efficiency, is always equal to 3,412 divided by the product of the mechanical and electrical efficiencies of the unit.

As a fair average value of the product of mechanical and generator efficiencies is about 0.94, it is readily seen that the B.t.u. rate on a non-condensing turbine is about 3,630 B.t.u. per kw.-hr., say 3,700 to be conservative or equivalent to less than $\frac{1}{3}$ lb. of coal. If the low value of 75 per cent for boiler and furnace efficiency is used and a generous 5 per cent allowed for auxiliaries, the plant B.t.u. rate is seen to be:

$$\frac{3{,}700 \times 1.05}{0.75} = 5180 \text{ B.t.u. per kw.-hr.}$$

Plant cost favors the byproduct non-condensing unit. The turbine itself is cheaper than other types and takes up less floor space. Condensing equipment is eliminated, and basement space is left available for other uses. Foundations may be simplified. A lighter crane may be used. Blade speeds are generally lower, and the moisture content of the steam in the lower stages is always less, both making for longer life and reduced repair.

The "topping turbine" is a special application of the non-condensing turbine and a good example of combined low cost and efficiency. It is applied to old low-pressure plants wherein the old boilers are discarded and new high-pressure boilers installed. The high-pressure steam expands through a non-condensing turbine before exhausting to the old low-pressure turbines. For instance, assume a plant operating with the time-honored steam conditions of 150 lb. pressure, 100 deg. F. superheat and 28 in. vacuum. Then add high-pressure boilers delivering steam at 600 lb. pressure and 200 deg. superheat and a non-condensing turbine. The improvement in the cycle reduces the fuel cost per kilowatt-hour approximately 20 per cent. Plant capacity is increased about 35 per cent, and the chief items of cost are new boilers and a turbo-generator rated at 35 per cent of the original plant rating. The new boiler with its furnace will probably be many per cent more efficient than the old, and judicious use of stage bleeding may help from 6 to 10 per cent. Thus the new equipment is soon paid for out of savings, since 35 per cent more power is generated with *little or no* increase in fuel.

Manufacturers of turbines have only recently been able to correlate their calculations to cover the greater part of the range. Considering that the turbine designer, in covering the range of industrial turbines from 150 lb. to 600 lb. pressure, must deal with steam flows varying up to 625,000 lb. per hr, with exhaust specific volumes varying from 1.5 to 26 cu.ft. per lb. and with the B.t.u. available in some cases as low as 55 and in others as high as 335, it will be seen what a task he has to develop a line of non-condensing turbines.

The curves are presented to assist engineers in the preliminary sizing up of a job. In spite of the wide range covered they will be found to be representative.

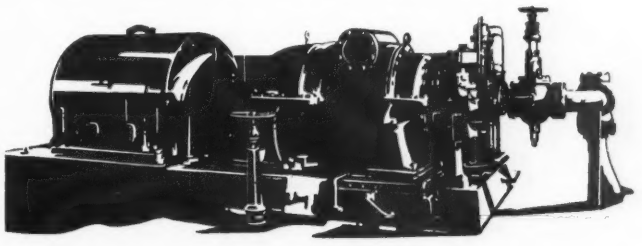
In making these curves, several measuring sticks were considered and discarded. Efficiency in itself means little when referring to a turbine generating byproduct power, as it has practically no direct effect on the coal pile and only a relatively small one on the amount of power generated. Then too, a steam chart must be used which makes the analysis more tedious and less direct. The B.t.u. rate, as noted in a previous paragraph, is practically a constant for a byproduct turbine, hence valueless for this purpose. Steam rate is the most frequently used criterion and could have been applied here, but it hardly seemed the most direct method of conveying the information intended. An engineer interested in a back-pressure turbine installation usually has a definite amount of steam to supply to process at a definite pressure. What he most wants to know is, "How many kilowatts can be generated from this steam?" or "What initial pressure must I have to obtain the desired by-product power?" With this condition in view, these curves have been made up to show the power recoverable from 1,000 lb. of steam per hour.

Use of these curves will be clarified by following throug the solution of a few problems. Assume a plant requiring 110,000 lb. per hr. of process steam at 30 lb. gage pressure and with boilers which can deliver this steam at 285 lb. gage pressure and 300 deg. F. superheat. The pressure ratio $\left(\frac{P_1}{P_2}\right) = \frac{300}{45} = 6.66$. Refer to the curves and follow the line of 6.66 pressure ratio upward until it intersects the curve labeled 300 deg. F. superheat. Read the rough value of kilowatts recovery on the scale at the left—41 kw. per 1,000 lb. of steam. There is 110,000 lb. of steam available, so a simple multiplication, $110 \times 41 = 4{,}510$ kw., gives us the approximate magnitude of the load. Return to the curves and follow the 41-kw. ordinate to its intersection with the 5,000-kw. rating curve and read on the top scale the value 43.5 kw. per 1,000 lb. of steam. Multiply this by the correction factor, 1.04, taken from the small curves at the right, and the kilowatt recovery is seen to be 45.2 kw. per 1,000 lb. of steam; with 110,000 lb. of steam available the byproduct power generated is 4,970 kw. The steam rate is $\frac{1{,}000}{45.2} = 22.1$ lb. per kw.-hr.

Assume a plant requiring 20,000 lb. of steam an hour at 10 lb. pressure, what pressure and superheat will be required in order that 750 kw. of byproduct power may be generated? With the flow and load fixed, the kilowatt recovery must be $\frac{750}{20} = 37.5$ kw. per 1,000 lb. Starting at 37.5 on the top scale of the curve and come down to the 750-kw. rating line. Then move across horizontally to one of the superheat lines—say 200 deg. F. The pressure ratio is read as 9.8. The throttle pressure must then be about $25 \times 9.8 = 245$ lb. abs. So far no account of the pressure correction has been taken. This may now be done by dividing the correction factor, 1.02, corresponding to 230 lb. pressure into the original figure for kilowatt recovery—$\frac{37.5}{1.02} =$ 36.8. Then go through the process again, starting at 36.8 on the top scale and obtaining a pressure ratio of 9.4 and a throttle pressure of 235 lb. abs.

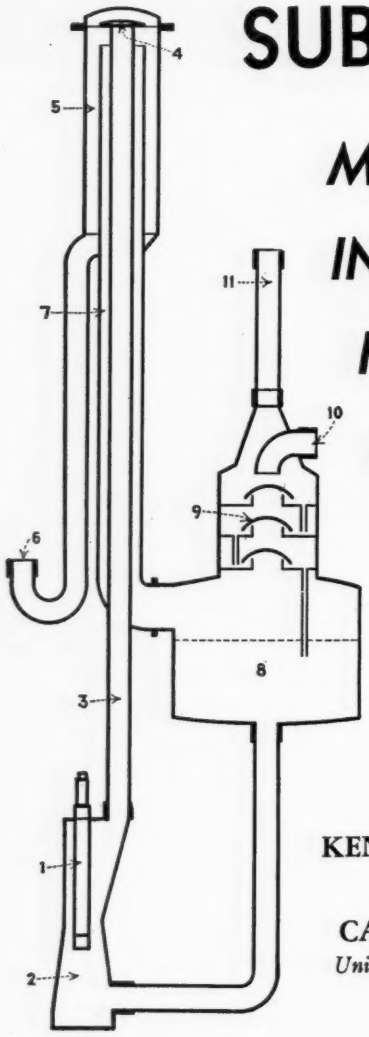
In the example just given, the superheat was chosen at random. Other superheats can be tried and the corresponding throttle pressure ascertained in the same way. It is advisable to select an initial superheat such that there will be no moisture in the exhaust. The condition of the exhaust steam can be determined easily with the help of a steam chart and a simple formula. Referring to the example in the previous paragraph, the heat initially in the steam at 265 lb. abs. and 200 deg. superheat is 1,319 B.t.u. The heat taken out of the steam is determined approximately by multiplying the kilowatt recovery by 3.2, thus: $37.5 \times 3.2 = 120$ B.t.u. The heat in the exhaust steam is $1{,}319 - 120 = 1{,}199$ B.t.u., and the corresponding superheat is read from the steam chart as 80 deg.

Often when turbine steam rates are given, it is desirable to know the quality of the exhaust steam. The heat taken from the steam can be determined closely by dividing the steam rate into 3,200. The heat in the exhaust is then obtained as in the previous paragraph. This approximate method gives results closer than 10 deg. F. superheat or 1 per cent of moisture over the range of ratings and conditions covered by Fig. 1.



SUBMERGED COMBUSTION

Meets Many INDUSTRIAL HEATING NEEDS



By
KENNETH A. KOBE
and
CARL W. HAUGE
University of Washington

Submerged combustion has advantages for hot-water heating systems and heating and concentrating various chemicals, but is not satisfactory for producing steam for power generation

HIGH efficiency and absence of scale difficulties would seem to make the submerged-combustion boiler ideal for power generation. There are disadvantages, however, due to the nature of the steam-gas mixture produced, which contains about 60 per cent steam and 40 per cent gas. An engine operating on this mixture will have the characteristics of both a steam engine and a gas engine. The steam-gas mixture does not have as high a specific heat as steam, so does not operate as efficiently in a steam cycle. A considerably higher boiler pressure must be used to have the steam-gas mixture at the same temperature as steam alone. The presence of the gas makes it impossible to use a condensing engine. The power consumption of the air compressor must not be overlooked. Thus, the internal combustion engine or the steam engine or turbine would appear more satisfactory for the production of power. In certain types of installations, however, the production of power may be a secondary factor. Here submerged combustion is ideal.

Recognizing the disadvantages of the Brunler boiler, Hammond has employed his gas burner for heating purposes. A water-heating system using a Hammond burner, shown, is installed on the top floor of a building to furnish a pressure head for the water. The burner (1) projects the hot products of combustion into the liquid in the circulator chamber (2). Gases in the small chamber act as an air-lift and raise the water up pipe (3) while heat transfer is taking place between the gas and liquid. The hot water is thrown against the deflector cover (4) and runs down into the head tank (5), which is kept full of hot water by the air-lift action. Hot water for the radiator system leaves at outlet (6). Gas and overflow water pass down pipe (7) to expansion tank (8). The gas passes upward through the bubble plates (9) counter-current to the downward flow of cold water entering at (10), which is returned from the radiators. The bubble plates provide further contact so that the gas leaving at (11) is at about the temperature of the cold water entering.

Thermostatic control to regulate the supply of gas to the burner can be applied to secure an immediate change in the rate of heating, whereas the inertia of the coal- or oil-fired boiler with such control allows a considerable time lag.

Hot gas from the burner, when projected into the water, is broken up into minute bubbles so that most of the heat transfer takes place in the air lift. The amount of surface available for heat transfer may be illustrated by visualizing 1 cu.ft. of gas which might be ordinarily contained by walls which would have 6 sq.ft. of surface for heat transfer. When 1 cu.ft. of hot gas is projected into water by the submerged-combustion burner, it is seen to split up into minute gas bubbles, most of which disappear into solution in the surrounding liquid, only to reappear at the surface in the same way as the gas at the surface of aerated water. It may be reasonably assumed that the mean size of these gas bubbles is that of a 0.001-in cube, thus the 1 cu.ft. of gas so divided results in a total area of contact of approximately 1.25 acres. The gas in the liquid decreases its density so that the liquid above the burner is forced upward by the denser column of water in the expansion tank.

A submerged-combustion system is the only one in which it is possible to utilize the latent heat of vaporization of the water formed in the combustion. A typical 3-day test, taken as part of a 12-month run, showed the exhaust gas leaving at 120 deg. F. and saturated with water vapor. This gave a heat recovery of 94.6 per cent of the gross heating value of the fuel. With such high efficiencies, the costs of such a system are below those of any other gas installation and compare favorably with those of oil and coal installations. The burner rated at 30,000 B.t.u. per hr. is equivalent to a sectional boiler rated at 63,825 B.t.u. per hr.

Since city gas contains a certain amount of sulphur, which would produce sulphur dioxide and with the gas charged with carbon dioxide, it might seem that corrosion would occur. Such has not been the case, for in a 60,000-B.t.u. per hr. plant, which operated over two years, no corrosion had been found. The pH of the

water in the system changed from an initial value of 8 to 6.7 over a 12-month period, an increase in acidity that could be taken care of by chemical treatment.

Chemical solutions are usually heated either by blowing in live steam or by steam coils immersed in the solution. In the former case, the solution is diluted greatly by the condensing steam, so it may be necessary to add more chemical to keep the solution at effective strength. In the latter case, corrosion of the steam coils may necessitate frequent replacement. For example, acid pickling baths are diluted to below effective strength by live steam, and the acid attack on steam coils requires frequent shutdown and renewal.

Submerged combustion solves this problem in an ideal manner. The products of combustion evaporate some water, so that a slight concentration of the solution may result if water is not added. The agitation effected by the bubbling products of combustion speeds up the operation and is usually responsible for a reduction in treating time. The same effect is found when heating soda-ash solutions for cleaning oil from metal parts. Acid electroplating baths often require heating, and here dilution and corrosion products are not allowable, so submerged combustion meets the need.

Special equipment has been developed for use in the dyeing industry. The burner is mounted in a closed kettle in such a way that circulation is obtained. Results with this apparatus at 180 deg. F. exceed the usual practice at 212 deg. F., at which temperature danger of shrinkage of the goods is much greater.

Chemical Concentration

The chemical industry abounds with heating and evaporation problems which subject equipment to the most severe conditions of direct chemical attack, corrosion and scale formation. These service conditions may be remedied by proper materials, provided that the material is not to be heated. Thus stoneware will effectively resist the attack of concentrated acids, but concentration by direct heat on the stoneware is not possible. By using submerged-combustion burners of special alloy, concentration is successfully effected in stoneware.

Brunler combines power generation with chemical concentration by using the chemical solution instead of water in the steam generator. The concentrated solution is removed from the generator; the steam-gas mixture produced is sufficient to run the compressors and give additional power.

Experiments at the University of Washington show that the concentration of sulphite waste liquor, a difficult problem of the sulphite pulp mills, is carried out successfully by submerged combustion.

Submerged combustion heating will invade the process-heating field and prove its merit on many difficult jobs. The practically complete utilization of the gross heating value of the fuel gives it an efficiency that makes it a competitor of steam heat and cheaper than electricity. Where chemical solutions must be heated, submerged combustion provides an efficient method that minimizes corrosion of equipment. It is no longer an experiment, but can be applied to heating problems.

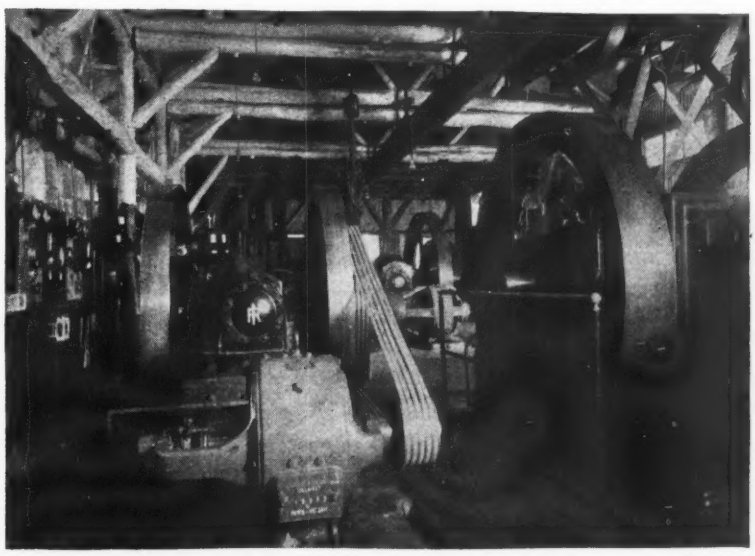
MOST ISOLATED POWER PLANT USES DIESELS

NINE months and 12,000 mi. from a repair part, the mines of Mutual Chemical Co. in New Caledonia have probably the world's most isolated power plant. This French island is 750 miles off the Queensland coast and 1,077 mi. from Sydney, Australia. Though the chrome and nickel ore mines of the company there have been worked since 1886, the decision to use air-driven tools was arrived at only recently. No water power is at hand, coal from Australia costs $14 a ton delivered and no power consultants or even first-class power engineers are available. Although fuel-oil cost is likewise high, the low-cost operation, ease of handling and maintenance and simplicity of diesel plant layout and design led the executives to choose this prime mover.

Four diesels were installed, all Carels-Ingersoll-Rand horizontal, single-cylinder, single-acting, solid-injection, cold-starting, 4-cycle units. One 110-hp., 260-r.p.m., 17x19-in. unit is direct-connected to a 2-stage 16½x13¼x19-in. compressor. The other 110-hp. unit is connected by multiple V-belt to a 70-kw. generator. Two 35-hp., 10.85x11.8-in., 350-r.p.m. units are each connected by multiple V-belt to a 23-kw. generator. Additional equipment includes two small gasoline-engine driven starting units and two centrifugal pumps for circulating cooling water. One of the small units and one of the large may be seen in the illustration, the other units being visible in the background.

Fuel oil for the engines comes from Balakpapan, New Guinea, to Noumea, port of the island, where it is transferred to 50-gal. drums for transshipment by coastal steamer and narrow-gage railway up to the mine. Water is taken from the mines or a nearby creek. Electric alarms warn of water shortage, high temperatures or low oil pressure, and recorders chart operation.

Oil for the plant is comparatively expensive. It costs, delivered, 3.35 francs per British Imperial gallon (about 13.13 cents with the franc at 3.92c.). Lubricating oil costs 35 francs a gallon.



HOW and WHY WE BURN

COTTON-SEED HULLS

By G. HOFFMAN
Chief Engineer, Southern Cotton Oil Company

HULLS from the cotton-seed oil industry are ordinarily used as cattle feed and fertilizer, but prices in these markets recently have been so low that it has become economically sound to use hulls as fuel, displacing coal, fuel oil and gas even in localities where these fuels are comparatively cheap. During the past two seasons, many oil mills have used hulls as fuel to produce their steam requirements.

Cotton-seed oil mills receive cotton seed from gins, which remove the long staple fiber. Seed, as received at the mills, still has on it a shorter cotton fiber called lint. Whether received in cars or trucks, it is weighed at the mill and samples are taken for analysis. For the purposes of this article, it is sufficient to say that ordinary seed contains hulls and meats as follows:

	Per cent	Lb. per ton
Hulls—(plus lint)	42.75	855
Meats	52.85	1,057
Trash, etc.	4.40	88

Seed is cleaned of all foreign matter such as sand, rocks, etc., and is then delinted by running through the mill's gins, or linters, as they are called. Here is removed a quantity of lint predetermined by the management. This, we will say, amounts to 120 lb. per ton of seed. The delinted seed, consisting of a husk (called hulls) and kernel (called meats) is then conveyed to the hullers which break up the seed, allowing the meats to be separated.

A certain quantity of hulls are ground by some mills to make what is called hull bran. This is mixed with the meats to make a cotton-seed meal. The hulls used for this purpose amount to 185 lb. per ton of seed, leaving 550 lb. of hulls per ton to be used as fuel.

Ordinarily, when hulls are sold by the mill, they are conveyed or blown from the separation machinery to cars or to storage. When hulls are used as fuel, they are sent to the boiler room by either of these methods.

After the hulls reach the boiler room, their disposal depends on the boiler-room equipment. If the furnace must be hand fired, the hulls are dropped to the boiler-room floor, then fed as required by hand with a pitchfork. Hand firing of hulls is such an unsatisfactory method, both in labor required and in efficiency of burning, compared to automatic feeding, so that only the latter method will be considered.

As it is not practical to gravitate hulls out of a storage bin or bunker, the common practice is to locate the feed conveyor or cyclone separator sufficiently high so that the hulls will gravitate to the point at which they are fed into the boiler. This is done by a spout leading from the bottom of the conveyor or cyclone directly into the boiler furnace. Angularity of this spout should be about 60 deg. with the horizontal, and it should not be less than 10 in. in diameter. Hulls have a tendency to pack and ball up, requiring a fairly large spout area.

If the boiler has a dutch-oven furnace, the spout should lead in through the oven top, and no other equipment is required to distribute the hulls. If they must be fed in through the furnace front, especially in large boilers, the hulls should be blown in with steam to get proper distribution. In this case, the end of the spout terminates in a sleeve of larger diameter than the spout. This sleeve leads into the boiler at about 30 deg. with the horizontal, and on the inside its center is about 3 ft. from the grates. It is desired that the hulls drop as near the center of the grates as possible. In the bottom of this sleeve outside the boiler front is a steam jet, directing the hulls as they fall through the spout onto the sleeve and into the boiler. The illustration shows an installation of this type in a 4,250-sq.ft. water-tube boiler equipped with a single-retort underfeed stoker. The purpose of the steam jet is to break up the balls or packed hulls and distribute them on the grates.

Cotton-seed hulls weigh 15 lb. per cu.ft., and though light and somewhat hard to handle, make an excellent fuel. The following is the fuel analysis:

	Per Cent
Moisture	11.25
Ash	2.52
Volatile Matter	68.81
Fixed Carbon	17.42
B.t.u. per lb. as fired	7,077

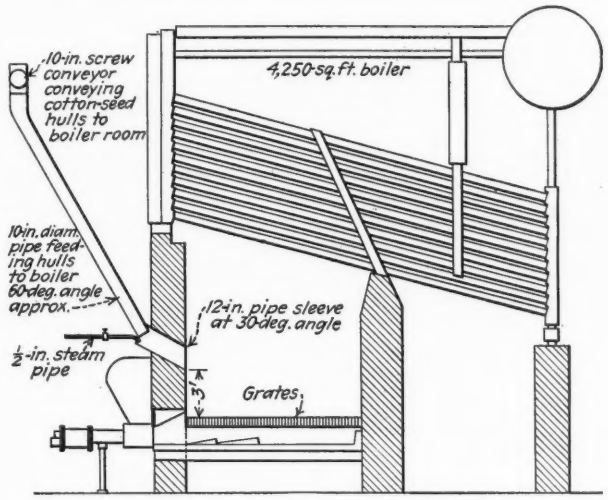
Most cotton-seed oil mill boilers are not designed to burn hulls with maximum efficiency. Those properly designed for burning pulverized fuel come nearest to being ideal for burning hulls from the standpoint of combustion space. In the installation illustrated, a large percentage of the hulls are burned in suspension. When being blown by the steam jet they are picked up by the draft and quickly carbonized. Some of them fall to the grates. Most of the fuel in suspension burns before reaching the boiler heating surfaces, but some continues to burn in the passes of the boiler and drop out into the last pass or chimney, or is carried out of the top of the stack. For this reason, high flue-gas temperatures are likely to exist, and do exist, particularly if the combustion is not kept within necessary limits.

There have been many oil-mill boiler plants in the South during the past two years which have burned hulls with disastrous results to their breachings and chimneys. It must be remembered that the necessity of burning hulls under oil-mill boilers is an unusual and infrequent occurrence and there has in the past, therefore, been no concerted effort to design boilers to use this fuel.

In the underfeed stoker installation illustrated, there are two boilers. Nothing whatever was done to the equipment except to install the hull feed as described. When burning hulls under these boilers, the stokers are of course not run, the grates remaining stationary. The forced-draft fan is run at such speed as to maintain zero windbox pressure, and 0.2-in. draft over the fire is main-

tained. Each of the two boilers is fed with 3,900 lb. of hulls per hour, equivalent to a seed crush of 340 tons per 24 hr.

Ashes from cotton-seed hulls, being small in amount (2.52 per cent of the weight of the hulls if completely burned) and of high gravity compared to that of the hulls, are easy to handle. Ash remaining on the grates is raked off into the ash pits, and from there removed in the usual manner. An equal quantity of ashes usually collects in the last pass of the boiler, being removed by raking out into a shallow steel box at regular intervals.


10-in. screw conveyor conveying cotton-seed hulls to boiler room
4,250-sq.ft. boiler
10-in. diam. pipe feeding hulls to boiler 60-deg. angle approx.
12-in. pipe sleeve at 30-deg. angle
½-in. steam pipe
Grates

Stoker-fired boiler arranged for using cotton-seed hulls as fuel

Cotton-seed hull ashes are valuable for their potash content, averaging 30-45 per cent water-soluble potash. The market price of such ashes during the mill season of 1932-1933 averaged $10 a ton, based on 30 per cent potash. Many mills having storage for ashes found a profitable market for this by-product.

No difficulty has been encountered in maintaining CO_2 percentages ranging from 16 to 18 per cent with no CO. Absence of CO is quite remarkable, considering that some combustion occurs in the last pass of the boiler. Another remarkable fact is that although these high CO_2 percentages exist in the flue gas, yet no difficulties are encountered with the settings. The explanation is probably that this fuel burns with dull incandescence, and furnace temperatures are comparatively low. Over-all efficiency as high as 75 per cent has been obtained on this equipment designed to burn coal. The fuel value of hulls compared to Kentucky screenings of 12,000 B.t.u. per lb. has been found to be 58 per cent of the value of the coal, when considering the steam produced alone. This value is somewhat higher considering that the expense of power, labor and maintenance on the coal-unloading equipment, power and maintenance on the coal-feed and stoker equipment, and about 30 per cent of the firing labor in the boiler rom is eliminated when burning hulls.

LIGHTING PULVERIZED COAL SAFELY

IGNITING pulverized coal has, in some installations, proved to be a somewhat hazardous job due to an occasional flare back through the burner. This was the case at the Hotel New Yorker where the pulverized-coal burners under the four 6,500-sq.ft. boilers were lighted with illuminating gas from the street mains. To light the burners, it was necessary for the operator to stand on the auxiliary platform in front of the burner and thrust the lighted gas burner into the furnace through a peep hole. Because of the restricted space, it was difficult for the operator to get out of the way in case of a burner flare back, which usually occurred when relighting a burner during light-load operation.

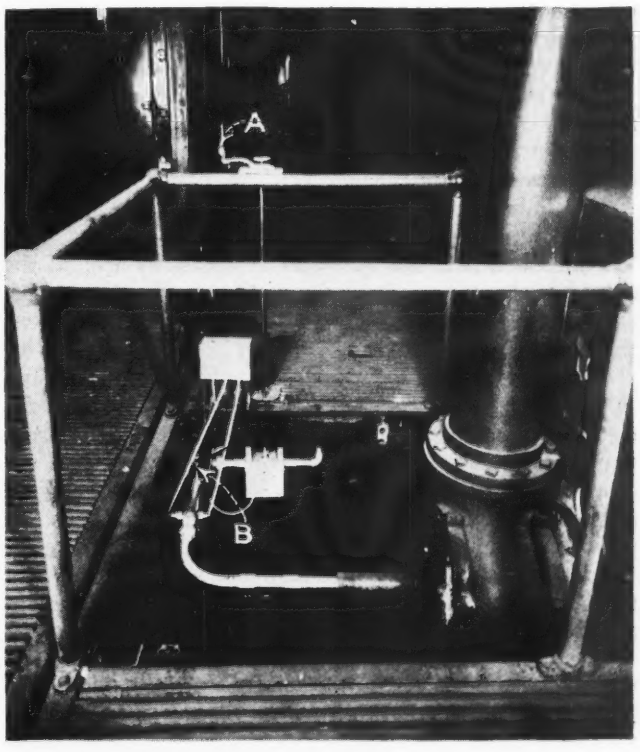
I. G. Carlsen, boiler room engineer, developed the idea of installing the gas torch permanently in the coal burner and igniting the gas with an electric spark. The device is quite simple both to operate and install. It consists of a special casting in which are inserted two high-tension spark plugs and a butterfly air-inlet check valve to prevent backfiring of the gas.

As installed at the New Yorker, the igniter is operated by the lever *A*, which, as it is turned, closes electrical contacts on the high-tension coil and opens a quarter-turn cock in the gas line. Turning the lever to the full extent of its travel turns off the electric ignition. The lever may be placed at any convenient location away from the burner, thus eliminating all danger to the operator from burner flare back.

The air-inlet check valve is arranged so that the air supply necessary for burning the gas is cut off when the draft in the furnace falls below 0.1 in. This protects the lighter against back fire in the gas burner and the furnace from explosion due to accumulation of combustible fuel.

The igniter has been installed on all of the boilers at the New Yorker and in addition to providing a safe method of lighting the coal burners, has also been found to save an appreciable amount of gas. It should be pointed out that the device can be used with oil- or gas-fired boilers as well as with pulverized coal.

This is a good example of management encouraging engineers to develop ideas, with resulting benefit to both.



Two separate oil-purifying systems, one for lubricating and governor oil and the other for transformer and circuit-breaker oil, provide for a wide range of operating flexibility

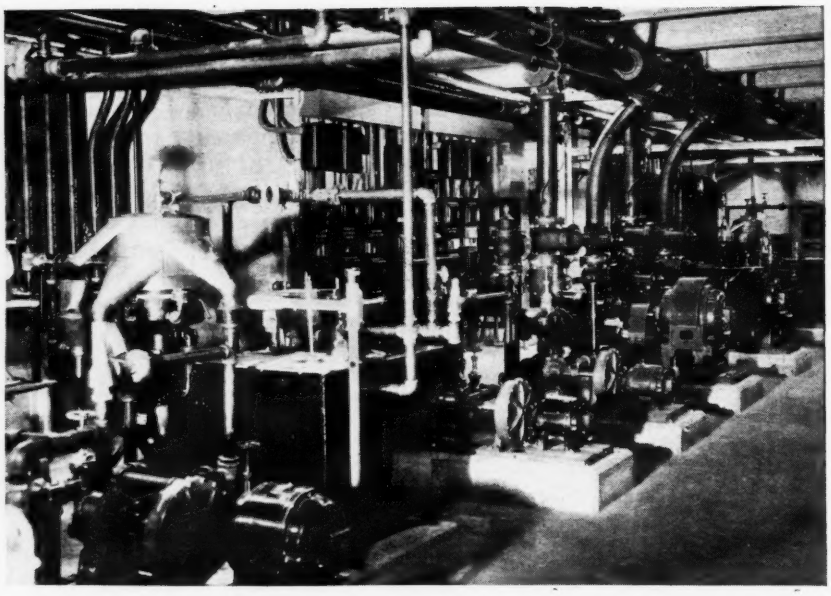


Fig. 1—Equipments for treating all oil used in the plant are installed in this room

SAFE-HARBOR PLANT HAS A DUAL OIL-PURIFYING SYSTEM

By J. B. CUTLER
Mechanical Engineer, Safe Harbor Water-Power Corporation

TWO separate oil-purification systems are installed in Safe-Harbor hydro station, near Columbia, Pa., one for handling the governor and lubricating oil and the other for the transformer and circuit-breaker oil. The centrifugal method of purification was chosen for its speed and the resulting low operating costs, and also its thorough separation of water and dirt.

Equipment for both systems is located in one room (Fig. 1). The purifier in the background is for governor and lubricating oils, both identical in quality and in characteristics. With this grade of oil, the machine can purify 500 g.p.h., sufficient to clean in 8 hr. the maximum oil capacity of one side of one governor sump tank.

The purifier in the foreground, Fig. 1, is for the transformer and circuit-breaker oil and has a capacity of 1,800 g.p.h., sufficient for cleaning all of the oil in one of the largest transformer tanks in 8 hr.

Fig. 2 is a diagram of piping connections around the separators, pumps and storage tanks. From these tanks the dirty-oil pump delivers the oil to the purifier either through the electric heater or a by-pass around the heater at a rate required to secure the proper degree of purification at the temperature desired. From the purifier, the cleaned oil is discharged into a collecting tank from which it is pumped by a clean-oil pumping unit to the clean-oil storage tank.

In the transformer and circuit-breaker oil system, provision is made for pumping the purified oil directly from the collecting tank through the clean-oil pump to the service location should it be desirable to do this in an emergency.

The oil heaters maintain the desired temperature of the oil through thermostatic control. These heaters are of the multi-pass type in which the heating elements do not come in contact with the oil. A relief valve, set to unload at approximately 45 lb. per sq.in., is provided to protect the heater from excess pressures such as might be developed by the pump if a stoppage occurred in the line between the heater and purifier. The heater's circuit is interlocked with the dirty-oil pump motor in such a way that heat can not be supplied to the oil until the motor circuit is energized.

Clean oil is discharged from the purifier into a collecting tank which serves as a reservoir in which air bubbles may be separated from the oil. This tank also serves as a safeguard against air being drawn through the clean oil pump which delivers the oil to the proper storage tank. The clean-oil pump motor is operated automatically by a float switch that starts the motor when the oil is above a given level in the collecting tank. This arrangement prevents the oil in the collecting tank from overflowing and also prevents the oil level from being made low enough to cause the pump to become air-bound.

Two sump tanks, installed on the floor directly under the oil-purifier room, collect leakage from various points in the system and receive oil drained from the system mains. One of these tanks is for the governor and lubricating oil and the other for the transformer and circuit-breaker oil. In the governor- and lubricating-oil system the sump tank also receives the drainage from the clean-oil pressure supply tank. In the transformer- and circuit-breaker-oil system the filter press is drained into this sump tank.

Each of these sump tanks is provided with a float switch that sounds an alarm in the purifier room when the oil level is near the top of the tank. Overflow is prevented by starting the dirty-oil pump to discharge the oil from the sump tank into the dirty-oil storage tank.

Drains from the pump bases are discharged into the 12-in. floor-drain header that discharges into the tailrace. It is probable that the drainage from the pump bases will sometimes include wash water and floor dirt making the oil unsuitable for purification.

To empty one of the large storage tanks for inspection and cleaning, the oil in it is pumped into another tank. After this has been done, any dirt or sludge remaining in the bottom of the tank may be drained off through a 4-in. line and then into the 12-in. drain header.

This 12-in. header was installed primarily to take care of the floor drains in the shore end of the plant and some of the outside drains on the intake deck. Four 8-in. drains in the oil-room floor are also connected with the 12-in. header, providing a means for quickly draining off any oil that may accumulate because of a fire or other emergency. This header was made large to meet these drainage requirements.

The use of one grade of oil for governor service and for lubrication purposes greatly simplifies the piping layout, making necessary only one supply and return main for this system, and serving also to reduce the number of clean- and dirty-oil storage tanks required.

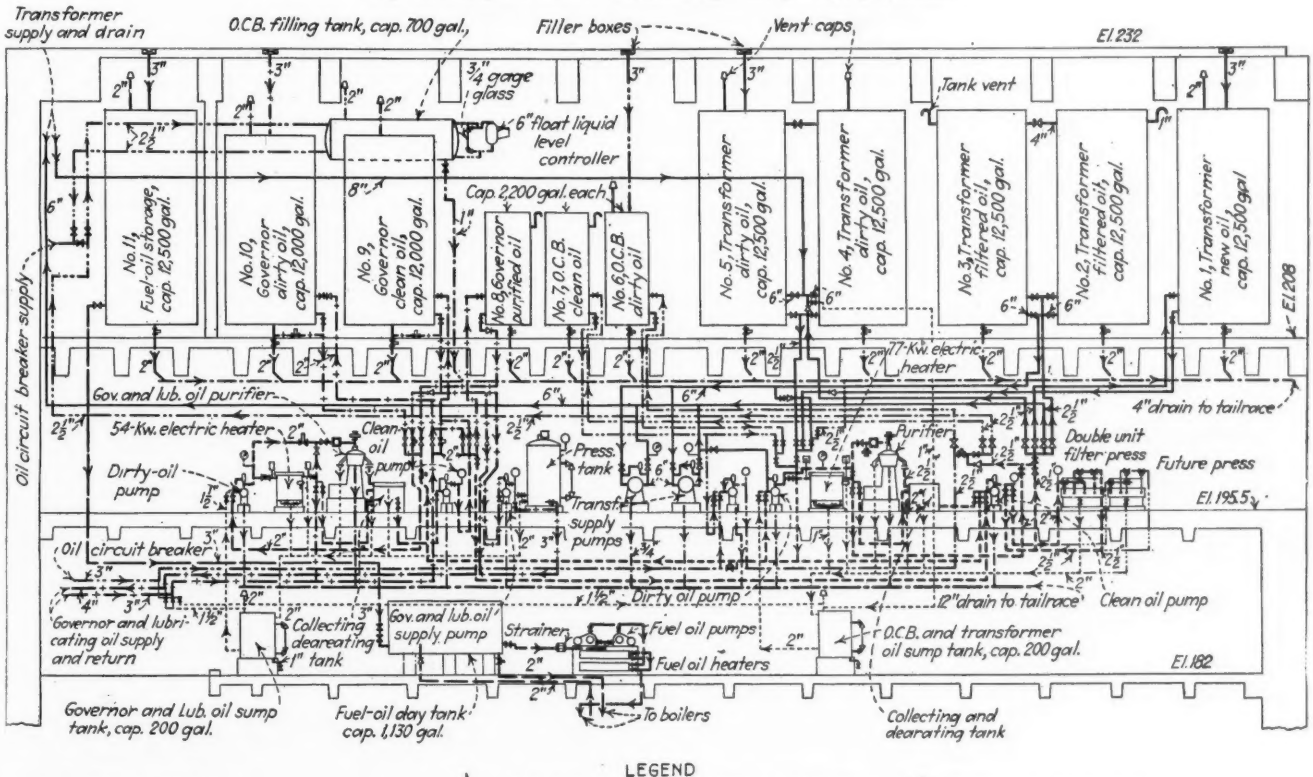
The pressure tank indicated in Fig. 2 near the governor-oil purifier is used as a pressure-storage reservoir for clean governor and lubricating oil, making clean oil instantly available at points in the system above the elevation of the storage tanks. Pressure is constantly maintained in this tank, and in the supply lines up to the valves at the service locations, through the operation of a small pump under pressure-switch control. With this arrangement, it is only necessary to open the valve at the location at which the oil is to be used to obtain a supply.

The same grade of transil oil is used for the transformers and circuit breakers, but two separate systems of supply and return piping are installed to carry the oil to and from the transformers and the circuit breakers. The separation of this oil is desirable, so that after being in use the oil for the transformers and for the circuit breakers will not be mixed to any appreciable extent. With this arrangement there will be less danger of carbon particles, resulting from electric-arcs that occur in the oil circuit-breaker tanks, getting into the transformers. The only parts of the systems where the transformer and the circuit-breaker oils pass through the same lines is around the purifier equipment.

The dirty oil is drained by gravity from the transformers to the dirty-oil tank. It may be returned to the transformers from the clean-oil tank through two gear-type pumps having a combined capacity of 1,000 g.p.m. Approximately 20 min. is required to drain one of the largest transformer tanks and about 15 min. is required for filling.

The dirty oil is removed from the circuit-breaker tanks and discharged into the dirty-oil storage tank in the circuit-breaker system through one 50-g.p.m. pumping unit. In returning the clean oil to the circuit breakers, this pump is used to lift the oil into a tank, from which it flows by gravity into the circuit-breaker tanks at low velocity to provide for smooth flow at the entrance and to prevent splashing over during the filling operation. The gravity-tank supply pump is operated automatically

Fig. 2—Diagram of the oil-handling- and purifying systems


Transformer supply and drain
O.C.B. filling tank, cap. 700 gal.
Filler boxes
Vent caps
El. 232
Tank vent
3/4" gage glass
6" float liquid level controller
Cap. 2,200 gal. each
No. 11, Fuel-oil storage, cap. 12,500 gal.
No. 10, Governor dirty oil, cap. 12,000 gal.
No. 9, Governor clean oil, cap. 12,000 gal.
No. 8, Governor purified oil
No. 7, O.C.B. clean oil
No. 6, O.C.B. dirty oil
No. 5, Transformer dirty oil, cap. 12,500 gal.
No. 4, Transformer dirty oil, cap. 12,500 gal.
No. 3, Transformer filtered oil, cap. 12,500 gal.
No. 2, Transformer filtered oil, cap. 12,500 gal.
No. 1, Transformer new oil, cap. 12,500 gal
El. 208
Oil circuit breaker supply
17-Kw. electric heater
Gov. and lub. oil purifier
4" drain to tailrace
54-Kw. electric heater
Clean-oil pump
Press. tank
Purifier
Double unit filter press
Future press
Dirty-oil pump
Transf. supply pumps
El. 195.5
Oil circuit breaker
Dirty oil pump
12" drain to tailrace
Clean oil pump
Governor and lubricating oil supply and return
Collecting deaerating 1" tank
Gov. and lub. oil supply pump
Strainer
Fuel oil pumps
O.C.B. and transformer oil sump tank, cap. 200 gal.
Fuel oil heaters
El. 182
Governor and lub. oil sump tank, cap. 200 gal.
Fuel-oil day tank cap. 1,130 gal.
To boilers
Collecting and dearating tank
LEGEND
Transformer oil
Circuit breaker oil
Governor and lubricating oil
Fuel oil
Oil circuit breaker and transf. oil
Circuit breaker, transf. or gov. and lub. oil
Drains to tailrace
Drains to sump tank
Future piping
Reducing pressure and diaphragm operated valve
Angle valve, normally open or closed
Normally closed valves, shaded
Lock shield gate valve, normally open or closed
Gate valve, normally open or closed
Globe valve, normally open or closed
Oil cock, normally open or closed
Three-way cock, normally open or closed
Pressure operated switch
Sylphon regulator valve
Quick opening gate valve, normally open or closed
Check valve
Relief valve
Vent cap
Flow-meter orifice
Indicating pressure gage
Indicating thermometer
Sight flow indicator

through a float switch, to prevent overflow of this tank while the circuit-breaker tanks are being filled.

In the transil-oil system, a double-unit blotter press is used to assist in the removal of any colloidal carbon particles not taken out in the purifier machine. This blotter press may be used in series with the purifier, or as a separate unit if desired.

Should it at any time become necessary to purify a portion of transil oil with the transil-oil purifier out of service, this may be done through the governor-oil purifier. Before doing this, the governor-oil lines through which the transil oil must be passed are thoroughly flushed.

Lock shield valves have been installed at the proper locations to guard against intermixture of the clean and dirty oil and of the different grades of oil. They are also installed in the drain lines under the storage tanks to guard against the loss of oil through carelessness in handling valves.

HEADER PATCH

Put on 400-Lb. Boiler

By WILLIAM R. MILLS

Boston, Mass.

A DANGEROUS bulge developed on a boiler operating at 400-lb. pressure in a large industrial power plant. This boiler had bow-type headers and the bulge was in the bottom trough of the front header. Two days before the week-end shutdown, a portion of a brick arch, directly above the pulverized-coal burners to protect the bottom of the header from high temperatures, collapsed. Because of demands for steam, the boiler was kept in service but at reduced rating. When the boiler was shut down at the end of the week, a severe bulging along the middle of the header trough was noticed.

When the bottom row of tube caps was removed, it was discovered that several inches of scale and sludge filled the trough almost to the bottom row of tubes. The scale, being a poor heat conductor, had allowed the temperature of the metal to increase until it was sufficiently weakened to bulge out from internal pressure.

It was desirable that the boiler be out of service for as short a time as possible for repair, yet that safety and freedom from leaks and future trouble be sure. In this case the repairs were made by two experienced boiler men, assisted by the regular plant repair crew.

The burned section of the trough was marked out for a 44-in. length by the boiler inspector, who then left the job to the boiler men. The trough was cut across its width at each end of this section with an acetylene torch. Rivets were removed from both seams in the tube and cap sheets, for three rivets beyond each end of the trough section to be taken out, as indicated in Fig. 1, and the burned section driven out with a sledge.

A piece of fire-box steel was fabricated at the boiler works, to the shape shown in Fig. 3, to replace the section removed. Rivet holes at the same pitch as those in the sheets were drilled across each end of the new piece. The two sides of the new trough piece were chipped at the ends and ground to a tapering point, as in Fig. 3. The taper extended back 2.5 times the pitch of the rivets along the trough-sheet seams where the three extra rivets were removed at each end. This allowed the ends of the new piece to come halfway between the second and third rivets from the cut. The new piece, which had the same strength and thickness as the original metal, had a base length sufficient to overlap the cut-out section by several inches at each end.

Wedges were driven in the seams by the third rivet removed beyond the cut, four wedges being used, one at each third rivet. The tube and cap sheets were heated with torches at these four points and the wedges driven in far enough to open the seam to admit the tapered ends of the new piece, which was then jacked into position, as in Fig. 4.

The new piece was then bolted firmly in position and rivet holes drilled in the ends of the original trough using the rivet holes in the new section as guides. The wedges were removed, the sheets heated and driven back for a good fit around the tapered ends of the trough section, after which the rivets were driven and the seams caulked. When the repair was completed, a 600-lb. hydrostatic test showed no leaks. The workmanship and method of repair were approved by both state and insurance-company boiler inspectors. The arch was rebuilt and the boiler placed in service. The boiler is now in operation and gives every evidence that a first-class repair job was done.

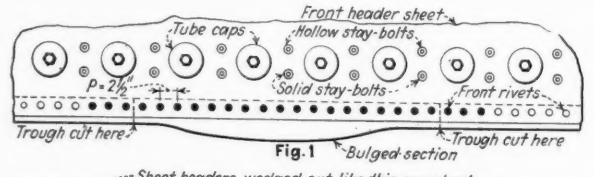


Fig. 1

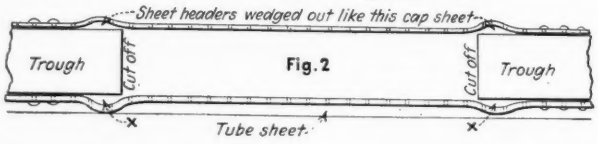


Fig. 2

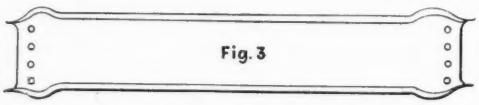


Fig. 3

Fig. 1—Shaded rivets are the ones removed from header to make the repair. Fig. 2—Bottom view of header before putting new trough piece in place. Fig. 3—Top view of new trough piece.

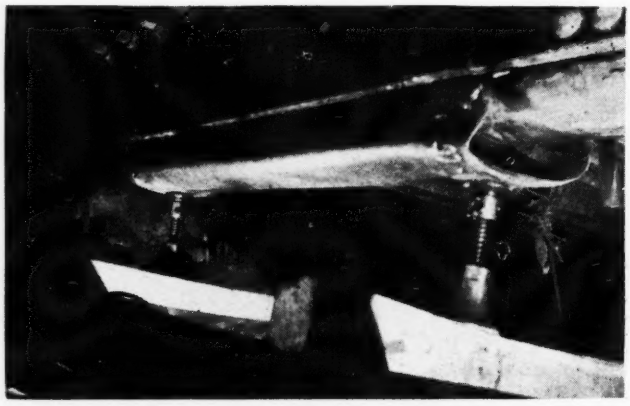


Fig. 4—New trough piece being jacked into place.

A REPLY TO MR. GOULD

By N. T. PEF

In the May and June numbers of *Power*, G. B. Gould, president of the Fuel Engineering Company of New York, set forth his views on selecting fuels. Discussion was invited. In this reply Mr. Pef strongly defends evaporation tests for fuel selection

MY EXPERIENCE checks Mr. Gould's observation that the fuel, and especially the coal, is too often made the scapegoat for all boiler room ills. But if the use of evaporative performance, as it is applied today, is "dangerous," this is because it is misapplied. The evaporation, when properly determined, is the most essential factor in the selection of a fuel.

The worth of the laboratory analysis is not to be underrated but it can no more replace operating results than the latter can be a substitute for the former. Each has essential uses. Analysis indicates the probable behavior of the coal; it is a starting point. Its other use is to check the coal merchant during the life of the contract, and to permit proper adjustments for any variation in quality. However, the final decision in the selection of a fuel must rest on the actual performance.

In order that the evaporation test may be of real value, certain rules must be observed:

1. The results must be expressed in units that have an economic significance. "Pounds of water per pound of fuel" indicates nothing. Why use meaningless language? If we are told that one coal has an evaporation of 10 and another of 9, this gives us absolutely no hint as to which of the two is better. Even if the results are reduced to pounds of water per 10,000 B.t.u. we still do not know which is the more economical fuel. Price must be included in the expression, as for instance, "pounds of water per dollar of fuel."

2. Variables not related to the burning quality of the fuel must be kept constant or their variations must be allowed for. Most important in this group is flue-gas temperature.

3. Adjustment must be made for those variables that are closely related to the burning quality. In this group, the CO_2 is the most important. Many combustion engineers believe that the CO_2 must be the same in two comparative trials. Yet it is more economical to burn natural gas with 10 per cent excess air than with 40 per cent, while with coal the reverse is true. With different coals the variation in excess air is not as great, but there is a difference and this should be observed. Each coal should be burned with that excess air which will produce the most economical result.

While many details must be considered in selecting a fuel, in the general case five values will suffice. These are: (1) The price, (2) heating value, (3) burning quality, (4) action on the refractory, (5) smoking tendency. The first three have already been considered.

Turning to the fourth, it is well known that different coals have various effects on the refractory. The lower the fusing temperature of the ash, the more rapid the erosion. This relation can be reduced to dollars and cents only by an actual trial, the period of which is considerably longer than for the evaporation test.

The smoking question can best be solved as Mr. Gould suggests. If the coal is known to smoke badly and the vicinity where it is to be burned is under strict smoke regulation, it cannot be considered.

Now we are in position to summarize our discussion by reviewing the steps in the actual selection of a coal.

1. A certain plant is burning coal whose price is 20c. per million B.t.u. and whose other characteristics are the best under the circumstances.

2. Another coal is brought up for consideration chiefly because its price is 18c., or 10 per cent lower, than the price now paid.

3. The smoke question can first be disposed of in the manner already suggested.

4. The next step is to analyze the coal and examine its characteristics to see whether the price advantage may not be offset by other considerations.

5. It is not likely that any adverse physical characteristics can offset a price margin of 10 per cent even when their negative effect is large. But if the price advantage is only 2 per cent, and the analysis indicates less desirable physical characteristics, a change of fuel is not warranted.

6. Assuming that the price difference is large enough to more than make up for any adverse result, sufficient coal may be bought for a trial of two or three days.

7. The coal is burned carefully, observing the rules already outlined, and the final result is expressed in pounds of steam generated per dollar of coal.

8. If the difference between the new figure and the old one is 4 per cent, it means that the 10 per cent original price margin has been reduced to a net gain of 6 per cent.

9. The next question is whether this 6 per cent gain can be nullified by an increase in the refractory maintenance. This is not likely, but if the margin is less than 2 per cent, and if the analysis shows that the coal has a much lower ash fusing temperature, its adoption will not be profitable.

10. Again we assume that the margin is large enough to take care of any possible increase in refractory costs, and an order is placed for the new coal. The main provision of the contract is that the price is to be on the basis of 18c. per million B.t.u., not so much per ton.

11. This does not terminate the fuel question. Certain routine must go on perpetually. The coal must be sampled and analyzed regularly, and the coal merchant must be held to the fulfilment of the contract.

12. The question of refractory maintenance can be settled by keeping a record of the cost of repairs and expressing this as a percentage of the coal cost. For instance, if during a year's time the coal bill is $50,000 and the refractory maintenance $2,000, this represents 4 per cent additional charge against the coal.

AUTOMATIC COMBUSTION CONTROL

By EDWARD S. BRISTOL

Combustion Engineer,
Leeds & Northrup Company

POWER-PLANT engineers generally consider that the greatest benefit is obtained from automatic combustion control when boilers operate under variable load. It is difficult for an operator to make frequent adjustments of combustion rate required under these conditions and still maintain proper combustion relations.

Although fuel and draft adjustments for steady output can be made manually with comparative ease, it is still possible for automatic control to be of practical advantage in securing the last increment of efficiency from base-load boilers. Automatic control also enables the operator to concentrate his attention on actual combustion conditions by relieving him of the necessity of making adjustments. Such advantages increase in dollar value with increase in boiler output, since the investment cost of control equipment is a smaller percentage of the total on large units. Complicated layouts of boiler auxiliary on large units constitute additional reason for use of automatic control, even under steady-load conditions.

An interesting example of automatic control on base-load conditions is that in the last addition to the South Meadow station of the Hartford Electric Light Company. The company is well known as the pioneer in commercial development of the mercury turbine. As an extension to this plant there was installed in 1929 a 40,000-kw. turbine generator and in 1930 a steam-generating unit having a maximum steam output of 450,000 lb. per hr. at 450 lb. per sq.in. and a total temperature of 725 deg. F.

Steam is delivered from the boiler directly to the new turbine, and there is also a connection through a reducing valve to the 275-lb. header of the older portion of the station. The new boiler, of the Stirling type, is fired with pulverized coal from four unit mills, two turbulent-type burners being supplied by each mill. Each mill has two feeders, which are linked to a feeder line-shaft common for the four mills, driven by either one of two variable-speed, direct-current motors.

Dual forced and induced-draft fans are provided. Each pair of fans is driven by two wound-rotor motors, one for low speeds and the other for high speeds. The two fans and the two motors are coupled together and rotate as a unit. Speed regulation for the forced-draft fans is obtained by a pair of mechanically coupled low- and high-speed pilot-motor-driven drum controllers. A similar pair of drum controllers regulates the induced-draft-fan speed. Motor change-over is incorporated with the drum controllers.

After the low-speed drum controller has reached maximum-speed position of the small fan motor, further movement transfers the drive to the large motor and speed control is then obtained from the high-speed drum. There is an overlap between the speed at which motor transfer takes place when increasing and the speed at which transfer takes place when decreasing the speed. This prevents frequent motor change-overs when operating near the transition point.

The plant normally operates on steady load, changes being made only at load-transition periods and according to a prearranged schedule. To take advantage of the new boiler's high economy, it is operated under automatic control on base load, with occasional major changes in output to meet station-load schedule.

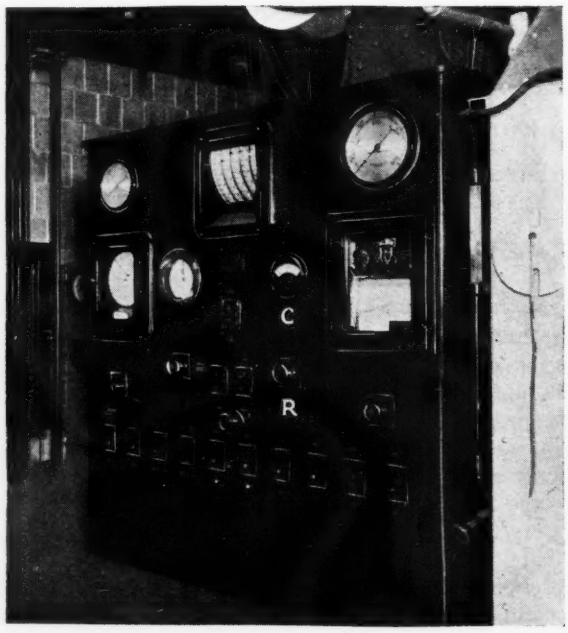


Fig. 1—Automatic combustion control panel

Automatic combustion control of the metering type is applied directly to the mill feeders and the draft dampers. A supplementary action regulates fan speeds as required to keep the dampers within a predetermined range. A control-rheostat indicator corresponds to the desired boiler output. The rheostat fixes the value of an electric control current acting on the fuel and air controllers. These set up loading forces that must be balanced by proportionate check-back forces representative of the actual fuel and air supplies.

An electric tachometer linked to the common feeder drive generates a voltage which serves as the fuel check-back force. The fuel controller balances this voltage against control current by actuating a motor-driven rheostat for the active feeder motor. A transfer switch connects the controller to either of the two feeder-motor rheostats. Mills can be cut in and out of service by a mill-selector switch on the control panel without disturbing the proper relation of fuel to air. This selector corrects the speed of the common feeder motor in accordance with the number of mills in service.

Fig. 3 shows the boiler front with the control panel at the left. It will be noted that provision is made for firing oil as an auxiliary fuel. Oil and pulverized coal are sometimes fired in combination, the combustion-control system being readily adjusted for this condition. An enlarged view of the control panel is shown in Fig. 1; the combustion-rate indicator is at *C* with the combustion-rate

OPERATES BASE-LOAD BOILER

Automatic combustion control generally shows most favorably on variable loads, but at the South Meadow plant, Hartford, Conn., it has been found economical on a steam-generating unit having 450,000-lb. per hr. capacity and operating on base load

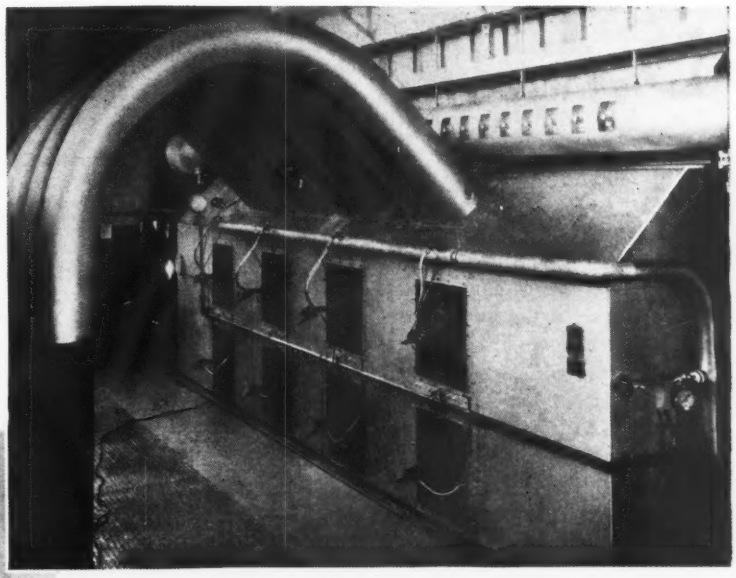


Fig. 3—Pulverized coal and oil can be fired in combination under this boiler by automatic combustion control

Fig. 2—Motor drive for forced-draft fan damper is at lower center

rheostat knob *R* directly below the combustion indicator.

Metered air-flow control is obtained by balancing the draft drop through a portion of the boiler against the electric control current. This regulating action is applied to a motor-drive unit for the boiler uptake damper. Forced draft is kept in step with induced draft by the furnace-pressure controller, which actuates a motor-drive unit for the forced-draft fan damper.

When either damper moves to its wide-open position or closes below a predetermined point, a switch on the damper-drive unit closes to actuate the pilot motor of the corresponding fan drum controller. Fan speeds are changed a step at a time, with a pause sufficient to allow the effect to react on the control before another is taken. The complete draft-control action utilizes the dampers to make the small, close adjustments and keeps the fans running at the minimum speeds for the existing load. Fig. 2 shows at lower center the motor drive unit for the forced-draft fan dampers, with cover removed to show the switch mechanism, immediately above the pilot motor, for controlling fan speed.

A complete system of interlocks is incorporated with the control in addition to the customary sequence interlocks for tripping out the forced-draft fans and mills in the event of induced-draft fan failure. Thus, smoke and improper combustion conditions are avoided at the upper limit of draft capacity by preventing an increase in fuel feed when draft is at a maximum. A similar interlock prevents a decrease of draft after the feeder speed has been decreased to a minimum.

Another interlock, added at the time of adjusting the control for service, prevents induced-draft fan speed from increasing faster than forced-draft fan speed. Without this interlock the slight time delay in forced-draft fan response was found to result in a high furnace suction under some conditions. Electrical boiler control readily permits the addition of interlock elements wherever necessary, an auxiliary limit switch or relay contact generally being all that is required.

This control system has been in operation since November, 1930, and, at the date of writing, has completed a two-year period with no service interruptions. The average time per week devoted to inspection and maintenance of the control equipment is two man-hours. It has been found possible with the control to hold combined boiler and furnace efficiencies that approximate those obtained under test conditions.

The automatic equipment has proved to be of considerable utility when making major changes of boiler output as required by the station loading schedule. The amount of supervision necessary to maintain desired operating conditions has been decreased by the control. In these ways automatic combustion control has thus justified its installation under conditions commonly considered unfavorable.

4-STEP POWER CONVERSION AT SPRINGWELLS

DETROIT'S "Springwells" pumping plant, one of the world's largest and finest, recently started regular operation after several years in construction. Embodying a complete steam-electric station, it is notable for its engineering completeness as well as for the size and architectural beauty of its structures. Some of its features are pictured on pages 472 and 473.

A detailed preliminary description of Springwells, with table of equipment (listing makers and contract prices), appeared in the March 24, 1931, number of *Power*. The present brief article, together with the photographs, supplements the previous article by picturing the completed job and reviewing briefly the features of the design.

River water, brought to the Springwells plant through 11 miles of concrete tunnel laid under the city streets, is handled in two steps by motor-driven pumps. The main power supply is a complete steam-turbine electric plant with central-station standby equivalent to one main turbine.

Low-lift pumps in a great concrete pit deliver the water to the filtration section of the plant. After purification, the water is pumped directly to city main by high-lift units mounted in eight relatively shallow rectangular pits. Present buildings will house an ultimate plant pumping capacity of 568,000,000 gal. per day and 20,000 kw. of turbine-generator capacity.

Electric pump drive was selected as the most reliable, economical and safe for the given conditions. Central-station standby connection makes unnecessary spare boilers and turbines. Electric drive of the pumps avoids the complication and danger of high-pressure steam lines in pump pits. High efficiency and good power factor of pump drives is obtained by using synchronous motors for the majority of the pumps, with slip-ring variable-speed, induction motors on certain units to provide for the fluctuating loads inherent in a plant delivering directly to the city mains.

1 BOILERS
2 TURBINES
3 MOTORS
4 PUMPS

The coal-handling sequence is: Incoming cars to crusher to pivoted carrier to belt conveyor to 600-ton overhead bunker to spouts to stoker hoppers. Ash is sluiced from stoker pits to a central pit equipped with clinker grinders. It is then pumped to an overhead tank for delivery to trucks or cars.

Steam Generation

Underfeed stokers, motor-driven, fire two (ultimately four) 10,000-sq.ft. bent-tube, water-tube boilers equipped with water-cooled side walls, economizers, air preheaters and superheaters. Forced and induced-draft fans (as well as pumps for feed, circulating water and condensate) are motor driven. Steam is generated at 360 lb. gage and 715 deg. F.

There are two (ultimately four) 5,000-kw. turbine generators, with 10,000-sq.ft. surface condensers. Steam for stage feed heating is bled at two points. In addition, three (ultimately four) 500-kw. condensing turbine-generator units, bled for building heating, are installed for auxiliary power supply.

On an elevated floor of the switch house, between boiler room and pump house, are two one-man control rooms, one for power plant and one for pumping plant.

The Pumping Plant

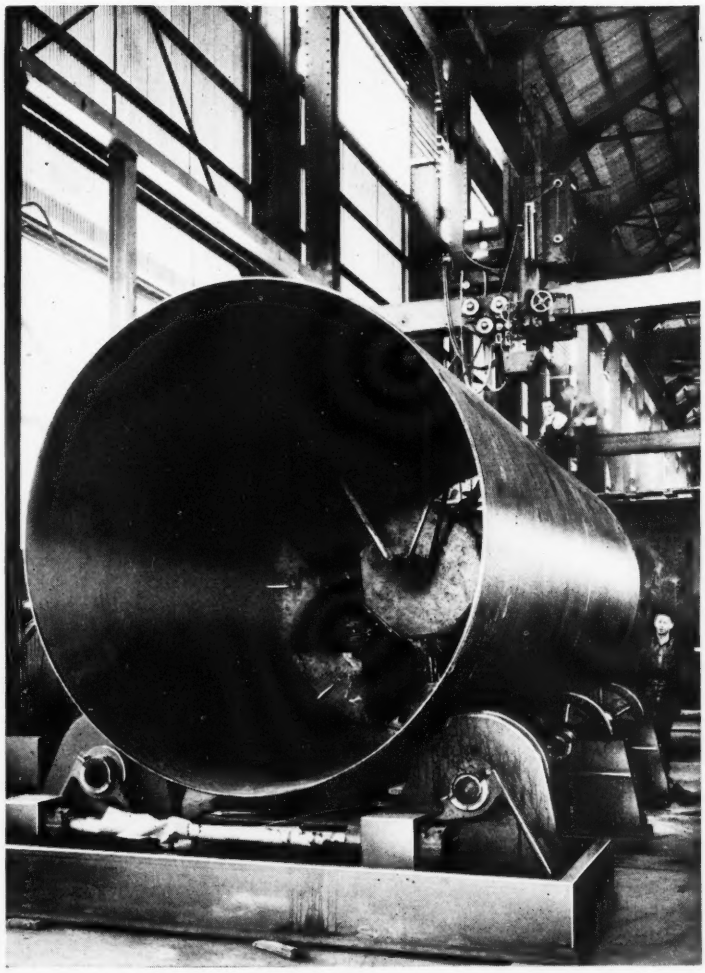
The visitor standing in the middle of the great pump room 108x386 ft. is surprised to see no pumping equipment. Nothing but the traveling crane is visible. Pumps and drives are sunk in pits, out of horizontal sight. A feature is the low-lift pump pit, a huge circular concrete structure whose outer wall, 8 ft. thick and 90 ft. in outside diameter, was sunk as a caisson 65 ft. below the bottom of a 25-ft. open-cut excavation, and then built up to a total depth of 110 ft. An inner shell, 58 ft. inside diameter, provides an annular space used partly for discharge flumes and partly as an inlet surge tank.

Near the bottom of this pit are placed the ten low-lift, vertical-shaft centrifugal pumps with a combined capacity of 435,000,000 gal. per day. The driving motors are placed much higher, above possible damage by flooding. Pump motors are predominately synchronous, but units aggregating about 30 per cent of the total capacity are driven by slip-ring, variable-speed, induction motors to handle load variations. Load fluctuates constantly.

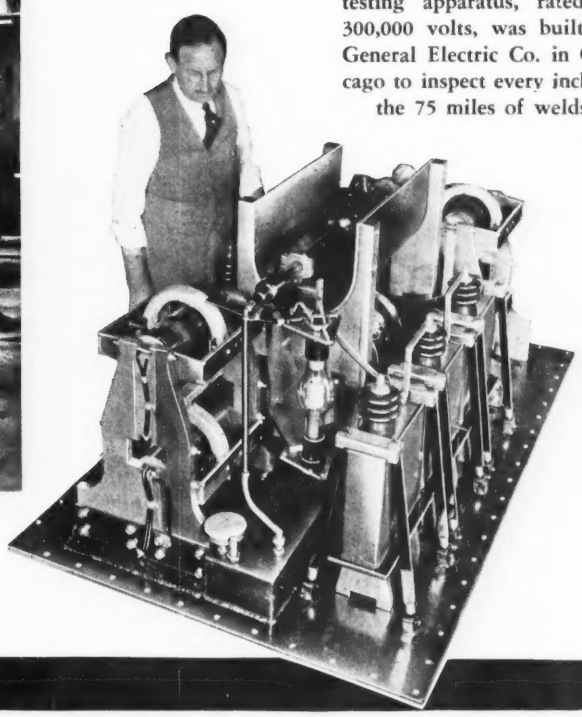
These low-lift pumps deliver to the purification plant, which returns the purified water to high-lift pumps for direct delivery to city mains. The 16 high-lift pumps, aggregating 568,000,000 gal.per-day capacity, are placed in eight shallow rectangular pits, two pumps to a pit. They are grouped for two heads, 130 ft. and 200 ft., for mains going to two different sections of the city. Like the low-lift pumps, the high-lift employ synchronous motors for the majority with slip-ring motors on a few pumps to carry load fluctuations. All main-pump motors (low-lift and high-lift) operate at 4600 volts.

This great plant was designed and constructed by Detroit's Board of Water Commissioners, under general direction of George H. Fenkell, general manager and chief engineer. The Bureau of Power, in charge of William C. Rudd, was responsible for the design and construction of pumping and power plants. Mechanical and hydraulic designs were supervised by Bernard J. Mullen, assistant mechanical engineer. Carl J. Schoeninger, assistant electrical inspector, was in charge of electric power, lighting and electrical equipment. Frank E. Simpson, associate structural engineer, was in charge of the structural design.

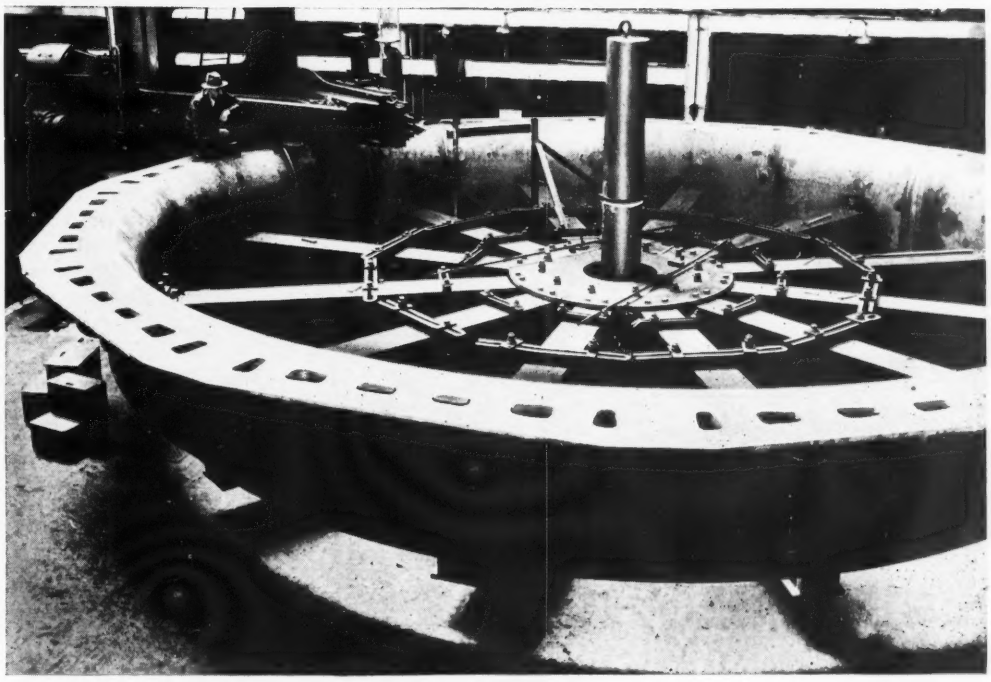
WELDING for BOULDER DAM



Two 8.5-ft. diameter pipe sections mounted on rolls under an automatic fusion-welding machine at the Boulder-Dam fabricating plant of the Babcock & Wilcox Company



Special shock-proof X-ray testing apparatus, rated at 300,000 volts, was built by General Electric Co. in Chicago to inspect every inch of the 75 miles of welds



Facing off the throat liners for Boulder Dam penstocks in the Westinghouse plant in East Pittsburgh. This steel casting weighs 40 tons and is 36 ft. in. outside diameter. An improvised boring machine required ten days to complete the facing, after which 912 holes were drilled through the 2-in-thick steel

•

STEAM CYLINDER

● A cylinder oil for use under dry steam conditions must satisfy the same four requirements as outlined for superheated steam in a previous monograph, namely:

1. Atomize quickly and completely.
2. Give complete and uniform coverage of valves and cylinders.
3. Replace any water present and resist removal by water.
4. Give maximum freedom from carbon and gummy deposits.

Although the same requirements must be satisfied, the relative importance of the various requirements is different and thus a different type of oil is required for best results with dry steam.

With dry steam it is more important that the oil replace any water present and resist removal by water. Even though the steam may be dry at the throttle, condensation of moisture will occur both during the expansion and the exhaust stroke. Despite this moisture the oil must maintain a lubricating film on all surfaces inside the cylinder and on the valves, otherwise wear and loss of power will occur.

The atomization of the oil must be quick and complete. It is somewhat easier to secure oil atomization with dry steam than with superheated steam since the little moisture usually entrained with the steam aids in oil atomization. The lower temperature of dry steam has less thinning effect upon the oil and to counteract this it is necessary to use somewhat lighter bodied cylinder oils. By the proper combination of cylinder stock and compounding material good atomization can be obtained.

To secure economical consumption the oil must give complete and uniform coverage of the valves and cylinders. Inferior oils that do not give a uniform film must be fed in excessive quantities resulting in the accumulation of pools of oil at some points and insufficient oil at other points. This causes increased trouble from cylinder deposits due to carbonization and gumming of the excess oil and in addition, increases lubrication costs.

The cylinder oil itself must be clean and free from any tendency to form carbon and gummy deposits. Otherwise even though it gives complete and uniform coverage and can be fed economically, trouble from deposits will occur.

Equal in importance to the selection of a cylinder oil is its application to the engine. The lubricant used may be the best product available and may be admirably suited to the steam conditions but if the method of application is improper, results will be unsatisfactory. To obtain the full effect of the velocity of the steam as an aid to atomization and to prevent the oil from dribbling down the inside of the steam pipe, the oil line should extend to the center of the steam pipe. A tip for the oil feed line consisting of a straight 3/8" pipe cut off square at the end functions well as an atomizer and does not readily clog up from deposits from the steam. The oil should be introduced into the steam line at least six feet ahead of the throttle unless limited to a shorter distance by the location of the separator.

The indirect method of oil application, namely, feeding all of the oil into the steam line, is in general the most satisfactory method for use with dry steam. It usually produces good lubrication with economy. However, on engines where the steam is used to jacket the cylinder and heads before entering the cylinder, some of the oil will be dropped out of suspension if it is fed into the steam line. Such conditions require that all or part of the oil be fed to it separately. In cross compound engines and other compound engines equipped with receivers, the receivers act somewhat as oil separators so that it is usually necessary to feed oil to the low pressure cylinder separately. Best results can be obtained by using the indirect method of oil feed here as in the high pressure cylinder.

After the proper cylinder oil for the operating conditions has been selected and it has been determined that the method of application is correct, the next step is to reduce the cylinder oil feed to a point consistent with good lubrication and economical oil consumption. The feed must be reduced gradually and frequent inspection of the interior of the engine should be made to determine the results secured. A well lubricated surface on cylinder walls, pistons and valves immediately after disassembling presents a dull, slightly oily appearance. A film of lubricant should be present sufficient to penetrate one thickness of cigarette paper and slightly stain the second when four or five thicknesses are pressed against the surface for about five seconds. This is a good check on the lubrication secured but it cannot be judged too exactly since it is affected by factor such as the temperature of the oil film, thickness of the paper and time of exposure. The test should be made immediately upon opening the engine.

From a consideration of the above it is seen that only by careful attention to the selection and correct application of the oil as well as proper adjustment of oil feed can maximum lubrication with economy be obtained.

NRA MEMBER U.S. WE DO OUR PART

STANDARD OIL COMPANY
(Indiana)
910 South Michigan Avenue Chicago, Illinois
1321

R LUBRICATION

Correct Lubricants Must Be Used For Effective Steam Cylinder Lubrication

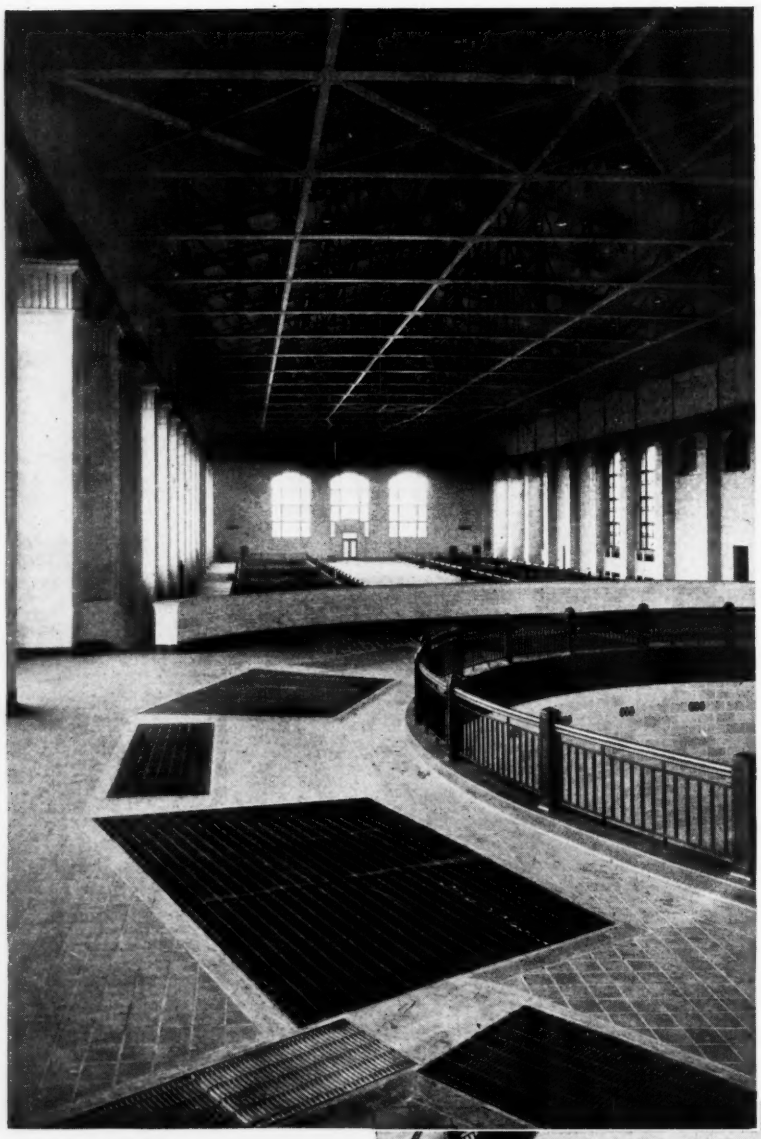
The correct lubricant for the cylinders of engines using dry steam must meet all four requirements emphasized in the monograph on the opposite page. StanoCyl D will do it effectively.

StanoCyl D is radically different from the conventional types of cylinder oils, and has characteristics never before combined in one oil. It will meet all conditions, except temperatures over 600°F. (Under such conditions StanoCyl S.H. should be used.) It atomizes quickly and completely, gives complete and uniform coverage of the valves and cylinders, will replace any water present, resists removal by water, and gives maximum freedom from carbon or gummy deposits.

Actual service in engines under different conditions of superheated steam has proved that StanoCyl D is definitely superior to other cylinder oils or so-called cylinder grease. Invariably oil consumption with StanoCyl has been reduced—sometimes as much as 50%. Additional savings also are made in maintenance and operating expense because of superior lubrication.

StanoCyl also may offer you considerable savings. One of our engineers will be glad to discuss the possibilities with you.

ENGINEERING



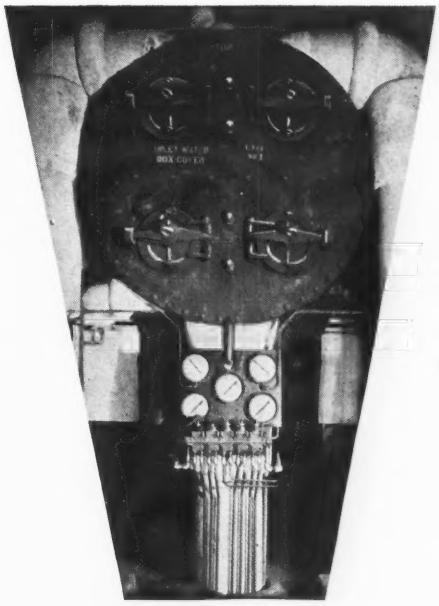
IN THE construction of Detroit's great Springwells pumping station, engineers and architects have joined hands to produce a power masterpiece. The station, now in operation, includes an extensive electrically driven pumping station, a complete steam turbine-generator power station supplying electricity for pump drive, and a large, completely housed water-purification plant. Photographs here shown were taken by a member of the *Power* staff. For further details, see page 470.

Pumping station proper. Mechanical equipment is entirely invisible in this general view. Low-lift pumps are in the circular pit, high-lift pumps in the eight rectangular pits in the background

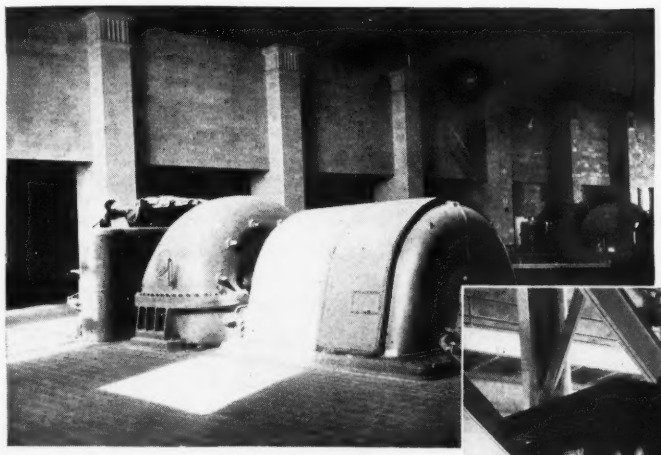
Six vertical synchronous and four slip-ring motors in the circular pit drive low-lift pumps (far below), with an aggregate capacity of 435 m.g.d.

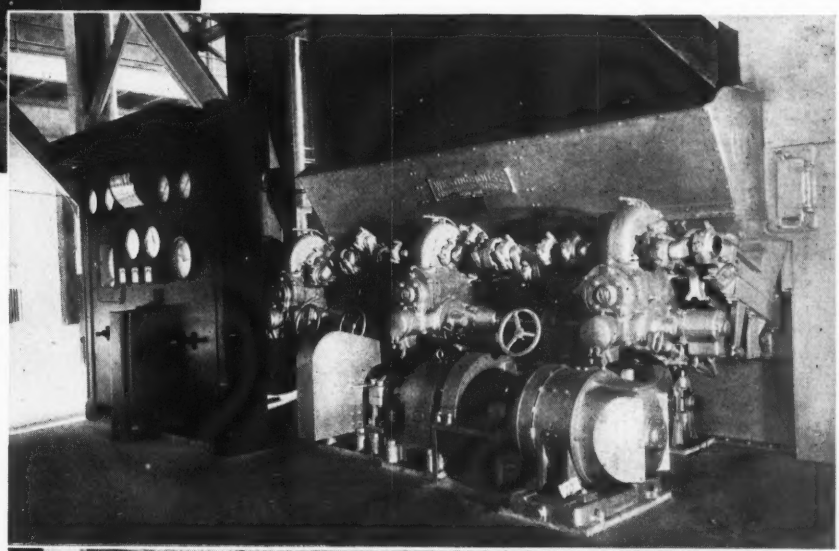
MASTERPIECE

Each 5,000-kw. turbine is served by a two-pass surface condenser designed for 28.5-in. vacuum with 7,850 g.p.m. of 70-deg. cooling water



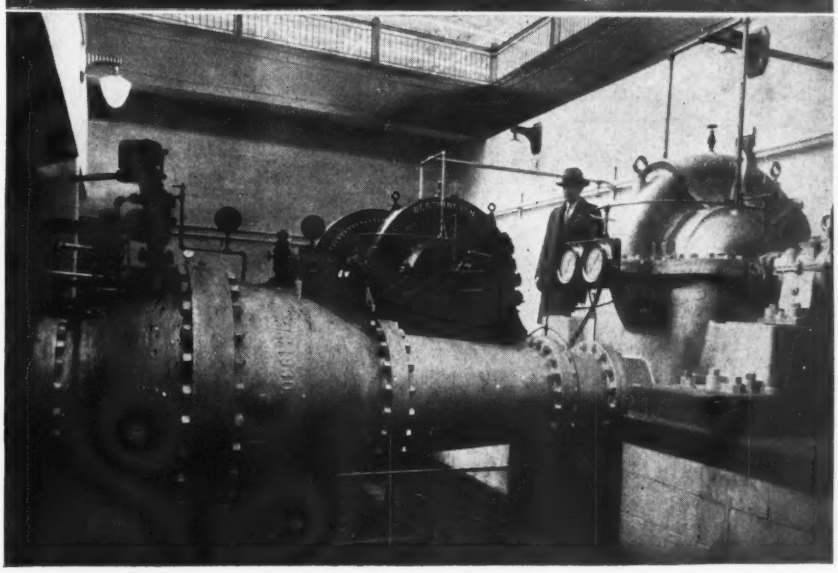
Two (ultimately four) 5,000-kw. steam-turbine units supply energy for pump operation



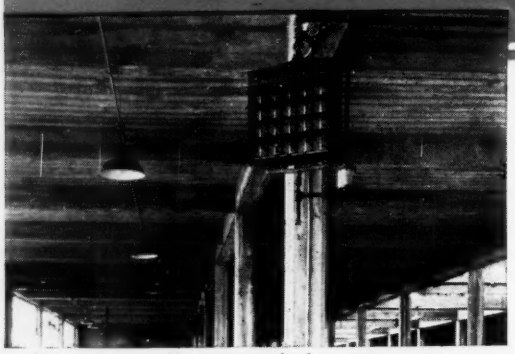


Steam for turbines is furnished by two 10,388-sq.ft. boilers, fired by underfeed stokers and equipped with superheaters, economizers and air heaters

View in one of the eight high-lift pump pits. Pump in foreground has capacity of 30 m.g.d. against 200-ft. head. Aggregate capacity of 16 high-head pumps now installed in eight pits is 568 m.g.d.



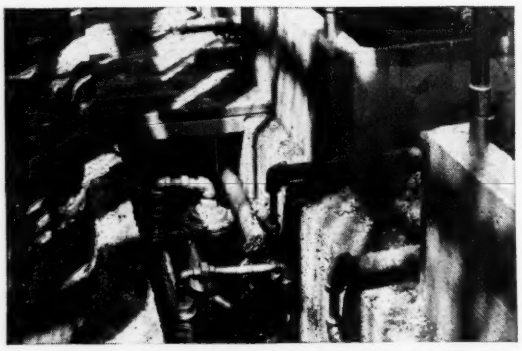
When you TURN ARMSTRONG



Even the smaller sizes of Armstrong traps have ample capacity for unit heaters. They are so light they can be supported entirely by the pipe lines in which they are connected.

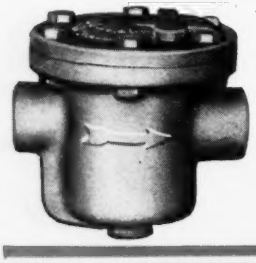
WILL GET MORE OUT SAME

The big air handling capacity of the Armstrong thermic unit is important in greenhouse heating. By breaking up the radiation into small units, each drained to a separate trap, short-circuiting is prevented.



Oil tank heaters must be drained for efficient operation. Oil companies know the reliability of Armstrong traps for this, as well as hundreds of other applications throughout the industry.

The trap below is the No. 100, smallest of the Armstrong line. At the opposite side is the No. 213, a medium-sized trap of wide application.

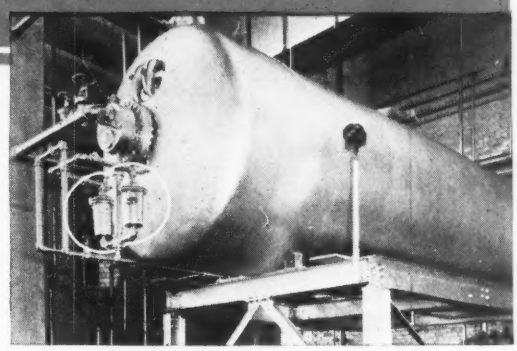


ARMSTRONG M

Three Rivers, Mi

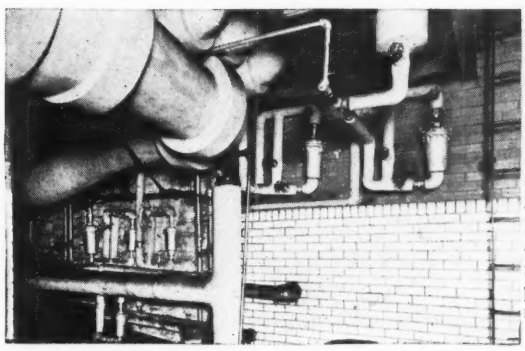
A SIZE AND TYPE F

ON THE STEAM TRAPS



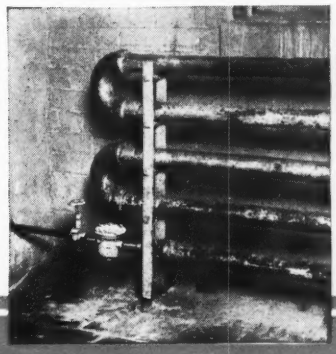
The application of traps to hot water heaters introduces some problems, which Armstrong traps have been successfully solving for many laundries, food products manufacturers and others. The local Armstrong representative is glad to consult on this or any other trap problem.

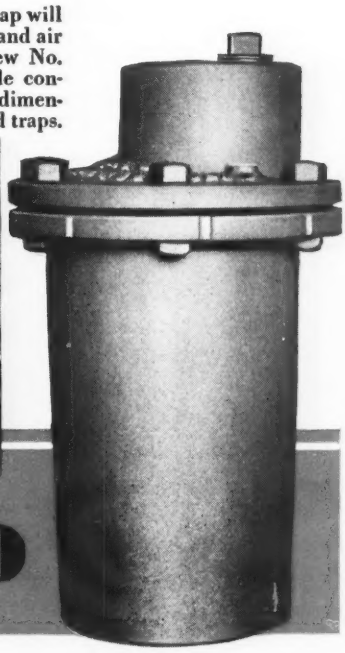
HEAT OF THE RADIATION



These Armstrong traps on the steam headers in a large institution have given trouble free service for many years. The simple construction and built-in quality of these traps make such experiences common.

A little No. 100 Armstrong trap will handle a lot of condensate and air from heating coils. The new No. 101 is similar but with angle connections having the same dimensions as other small standard traps.





MACHINE WORKS

Michigan

FOR EVERY NEED

OIL MEASUREMENT TABLE AT 60 DEG. F.

Gravity Degrees A. P. I.	Specific Gravity	Lb. per Gallon	B.t.u. Per Lb.	B.t.u. Per Gal.	Lb. per 42-Gal. Barrel	Weight Lb. per Cubic Ft.	Cubic Ft. Per Ton 2,240 Lbs.	Gals. per Ton of 2,240 Lb.
3	1.0520	8.76	18,190	159,340	368.00	65.54	34.17	255.65
4	1.0443	8.69	18,240	158,500	365.31	65.07	34.42	257.54
5	1.0366	8.63	18,290	157,840	362.62	64.59	34.68	259.48
6	1.0291	8.57	18,340	157,170	359.98	64.12	34.93	261.37
7	1.0217	8.50	18,390	156,320	357.37	63.65	35.18	263.26
8	1.0143	8.44	18,440	155,340	354.81	63.19	35.44	265.15
9	1.0071	8.39	18,490	155,130	352.46	62.78	35.68	266.91
10	1.0000	8.33	18,540	154,620	350.15	62.36	35.91	268.67
11	.9930	8.27	18,590	153,740	347.71	61.93	36.16	270.56
12	.9861	8.22	18,640	153,220	345.28	61.50	36.42	272.50
13	.9792	8.16	18,690	152,510	342.88	61.07	36.67	274.39
14	.9725	8.10	18,740	151,790	340.53	60.65	36.93	276.28
15	.9659	8.05	18,790	151,260	338.22	60.24	37.18	278.17
16	.9593	7.99	18,840	150,530	335.91	59.83	37.43	280.06
17	.9529	7.94	18,890	149,980	333.64	59.42	37.69	281.99
18	.9465	7.89	18,930	149,360	331.42	59.03	37.94	283.88
19	.9402	7.83	18,980	148,610	329.23	58.64	38.19	285.77
20	.9340	7.78	19,020	147,980	327.05	58.25	38.45	287.66
21	.9279	7.73	19,060	147,330	324.91	57.87	38.70	289.55
22	.9218	7.68	19,110	146,760	322.81	57.49	38.95	291.44
23	.9159	7.63	19,150	146,110	320.71	57.12	39.21	293.37
24	.9100	7.58	19,190	145,460	318.65	56.75	39.46	295.26
25	.9042	7.53	19,230	144,800	316.59	56.39	39.72	297.15
26	.8984	7.49	19,270	144,330	314.58	56.03	39.97	299.08
27	.8927	7.44	19,310	143,670	312.60	55.68	40.22	300.97
28	.8871	7.39	19,350	142,990	310.63	55.32	40.48	302.86
29	.8816	7.35	19,380	142,440	308.70	54.98	40.73	304.75
30	.8762	7.30	19,420	141,770	306.81	54.64	40.98	306.64
31	.8708	7.26	19,450	141,210	304.92	54.31	41.24	308.53
32	.8654	7.21	19,490	140,520	303.03	53.97	41.50	310.46
33	.8602	7.17	19,520	139,960	301.18	53.64	41.75	312.35
34	.8550	7.12	19,560	139,270	299.37	53.32	42.00	314.24
35	.8498	7.08	19,590	138,690	297.57	53.00	42.26	316.18
36	.8448	7.04	19,620	138,120	295.80	52.68	42.51	318.07
37	.8398	7.00	19,650	137,550	294.04	52.37	42.76	319.96
38	.8348	6.96	19,680	136,970	292.32	52.06	43.02	321.85
39	.8299	6.92	19,720	136,460	290.64	51.76	43.26	323.69
40	.8251	6.87	19,750	135,680	288.91	51.46	43.52	325.63
41	.8203	6.83	19,780	135,090	287.23	51.16	43.78	327.52
42	.8156	6.79	19,810	134,510	285.55	50.86	44.04	329.45

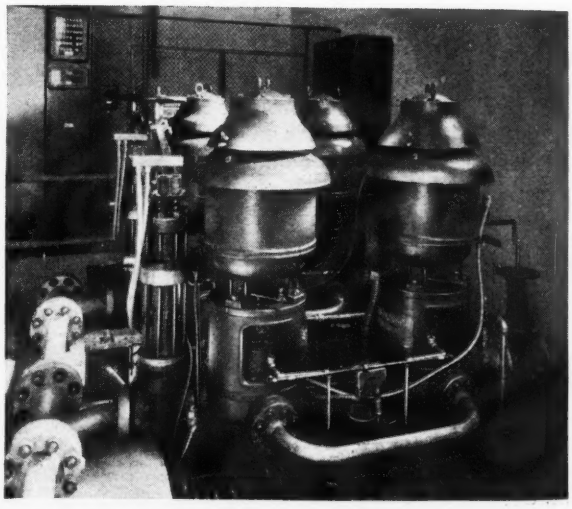
The above relation between specific gravity and A.P.I. degrees is expressed by the formula $\frac{141.5}{131.5^\circ + \text{A.P.I.}^\circ}$ = Sp. Gr. at 60 deg. F.

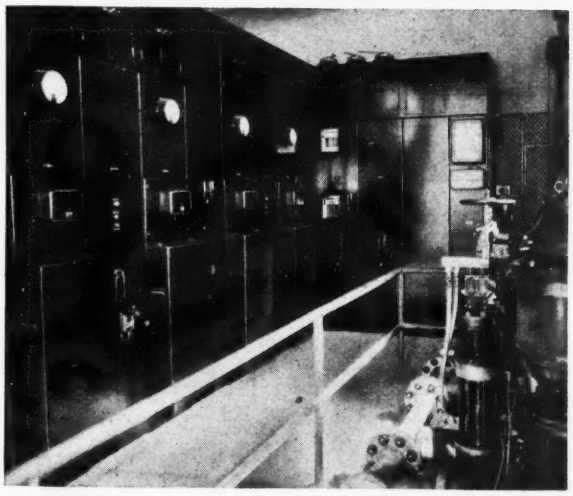
For each 10° F. above 60° F. add 0.7° A P. I.

For each 10° F. below 60° F. subtract 0.7° A. P I.

WATER PUMPED OUT OF GRAND CANYON

Under 2/3-Mi. Head





Top—Each pair of pumps operate in series against a 3,500-ft. head. Below—Starting panels and supervisory control panel for the pump motors

PUMPS have succeeded water trains in supplying water to El Tovar Hotel and cottages, on the rim of Grand Canyon, nearly a mile above the Colorado River. From 1901, when its first train ran into the Canyon, until August of last year, the Santa Fe Railway had hauled nearly a billion gallons of water 99 mi. from Flagstaff, Ariz., lately averaging 100,000 gal. per day.

But water demands and transportation costs continued to increase. So now Indian Garden Springs, 3,153 ft. below the Canyon rim and 1,200 ft. above the river, supply the water through two pumping units, each consisting of two 17-stage centrifugal pumps in series. Water is collected in a 70,000-gal. reinforced-concrete reservoir, with a secondary reservoir created by a submerged dam 200 ft. lower down. Auxiliary pumps lift this supply to the main reservoir.

The two vertical, high-pressure, Byron Jackson main pumping units are each capable of delivering 85 g.p.m. (120,000 g.p.d.) to an 800,000-gal. storage reservoir (10 days' supply) against a total head of nearly 3,500 ft., 3,166 ft. being vertical lift and the balance friction in the 12,000-ft. pipe line.

Each pump is directly driven at 3,600 r.p.m. by a General Electric 2,300-volt, 60-hp., squirrel-cage induction motor. The discharge pipe line, together with the armored power cable and control cable, have been camouflaged under direction of the National Park Service, whose primary requirement was that all cables and pipe be installed without marring Canyon beauty.

Because of the isolated location, manual control of pumps and valves was eliminated. A power-house engineer operates the station from the rim of the Canyon through a Westinghouse Visicode system of remote control. This also provides continuous individual indicating lamp supervision over the same two No. 10 telephone-type line wires. Control is arranged so that the power-house attendant can:

1. Start, stop and receive an indication of what is happening (running or stopped) of either unit. (Control also provided for future third unit).
2. Open, close and receive an indication of position (open or closed) of drain valve.
3. Control and receive an indication of position of the check-valve jackscrew adjustment.
4. Receive an indication of low water in the reservoir.
5. Receive low-temperature indication.
6. Ring and connect telephones at each station to line wires, using supervisory system wires.

Automatic starters on the pump motors limit starting current to 140 per cent of running current. Contacts for starting and stopping, pushbutton operated in manual stations, here are operated by the supervisory control. An interlock on the starting compensator operates when the motor is connected to full-line voltage to control the supervisory lamp signals.

A motor-operated drain valve is provided to permit the operator to empty the pipe line when necessary. This valve can be opened or closed independently with the supervisory control. Limit switches control valve travel, once an operation has been initiated by the control, thus insuring full valve travel. The check valve is not operated directly by the control, but is controlled by the gate valves which operate automatically as a part of the starting and stopping sequence initiated by the control. However, this control is supplemented by a supervisory-controlled adjustment for throttling the flow to a predetermined quantity, by a motor-driven jackscrew which limits check-valve travel in the opening direction. The supervisory control permits setting the jackscrew in either of two predetermined stop positions, one throttled, the other full open. Lamps indicate the position.

Part of the upper section of the pipe line is exposed where rock cliffs made trenching impractical. To guard against freezing, a thermostat at the coldest section of the pipe operates alarms on the supervisory panel.

Four float switches, one for each unit, one for automatic control of the auxiliary pumps at the submerged dam and one for a low-water alarm, are installed in the pumping station reservoir.

REDUCING PEAK LOADS

Maximum demand of power loads may be controlled automatically and the cost of power reduced. Here's how it's done

WHEN power is purchased to operate an industrial plant, the engineer has many opportunities for keeping down its cost, just as when power is generated in an isolated plant. Means used to reduce the cost may vary for the two conditions, but the saving in either case may be large. Consequently, the factors influencing the cost of purchased power are worthy of the same intelligent study as are those that enter into the cost of generating power.

Most power-company rates for industrial power include both a demand and an energy charge. The demand charge is assumed to cover that part of the cost of serving the customer that is a fixed annual expense, such as interest on investment in equipment to render the service. The energy charge is to take care of costs that vary according to kilowatt-hours used by the customer. In the latter, where power is supplied from a steam plant, a large part of these costs is for fuel.

How power cost may be reduced by keeping down the maximum demand is the subject of this article. Rate schedules vary widely with different power companies, load served and kind of service rendered, but the following is a typical two-charge rate:

Demand Charge

First 500 kw.	per kw.	$2.50 per month
All over 500 kw.	per kw.	$1.50 per month

Energy Charge

First 1,000 kw.-hr. per month	2.5	c. per kw.-hr.
Next 1,500 " " "	2.0	" " "
" 2,500 " " "	1.5	" " "
" 5,000 " " "	1.0	" " "
" 190,000 " " "	0.85	" " "
" 300,000 " " "	0.75	" " "
All over 500,000 kw.-hr. per month	0.65	" " "

For some cases the highest single 15-min. demand occurring in a month is taken for billing purposes; in others, it may be on a basis of 1, 2, 3, 5, 10, 30 or 60 min. Some rate schedules call for an established monthly demand holding for the next eleven months. Frequently several of the highest demands are averaged to establish the billing demand.

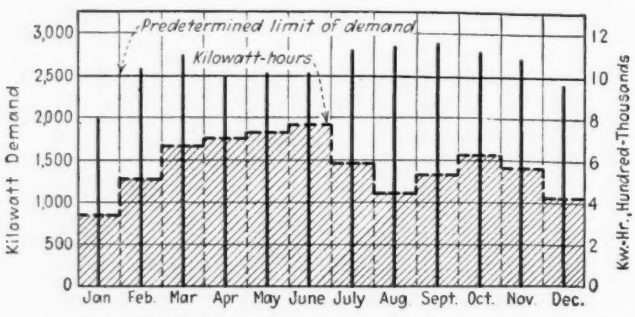


Fig. 1—Monthly kilowatt demand and kilowatt-hours used in a large industrial plant

Most industrial plants have a wide variation in kilowatt demand during each 24-hr. and monthly period. Fig. 1 is a typical yearly power curve for a large industrial. It will be noted that during several months the kilowatt-hour use was low, but that in some of these months the kilowatt demands were excessive. Obviously, if the monthly demands could have been reduced, as they could have, the power cost would have been reduced.

For example, assume that the maximum demand had not been allowed to go above 2,500 kw. This would have resulted in a reduction in February of 100; March, 250; May, 50; June, 50; July, 300; August, 350; September, 400; October, 300; November, 200 kw., a total of 2,000 kw. for the year. At $1.50 per kw., this is a saving of $2{,}000 \times 1.50 = \$3{,}000$ obtained by reducing the demand a small amount for a few months in one year.

An excellent example of excessive demand is shown in the curves, Fig. 2, presented in an article, "Purchased Public Utility Power," by W. B. Skinkle, engineer, Pittsburgh District Power Committee, United States Steel Corp., appearing in the Engineer's Society of

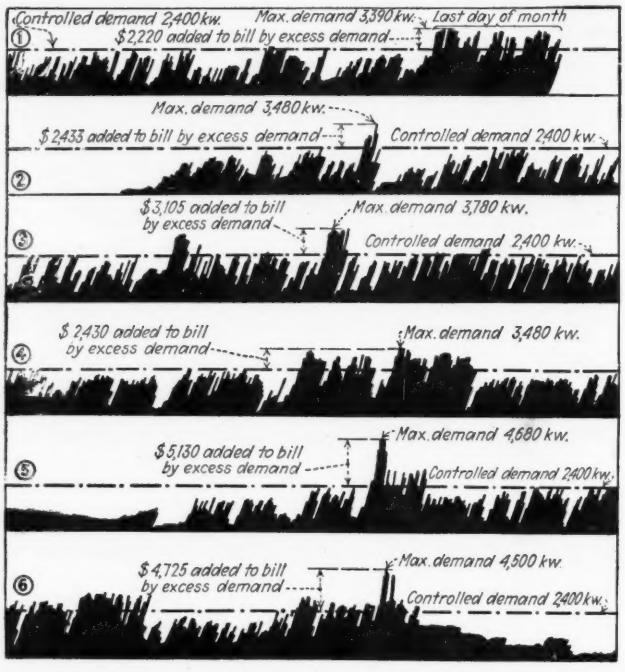

Controlled demand 2,400 kw.
Max. demand 3,390 kw.
Last day of month
$2,220 added to bill by excess demand
1
Max. demand 3,480 kw.
$2,433 added to bill by excess demand
Controlled demand 2,400 kw.
2
$3,105 added to bill by excess demand
Max. demand 3,780 kw.
Controlled demand 2,400 kw.
3
$2,430 added to bill by excess demand
Max. demand 3,480 kw.
4
Max. demand 4,680 kw.
$5,130 added to bill by excess demand
Controlled demand 2,400 kw.
5
$4,725 added to bill by excess demand
Max. demand 4,500 kw.
Controlled demand 2,400 kw.
6

Fig. 2—Excess monthly demands in a large industrial plant

Western Pennsylvania proceedings. These curves emphasize the relatively few times in a given month that high peak loads occur.

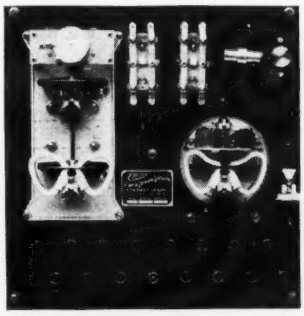
Mr. Skinkle states "It is believed that with proper load-controlling devices, this plant could operate on a demand of 2,400 kw. which has been called the controlled demand. Regularly at the end of each month, the department superintendents hear the cry from the manager —'Get those orders shipped and into this month's busi-

CUTS POWER COSTS

By EDWARD T. MOORE
Syracuse, N. Y.

ness.' Note the answer of the superintendent's driving for the greatest possible output on the last days of the month. This is shown by the fairly uniform increases in the use of power.

"Also note the increase in the demand charge on the power bill. This increase, owing to the excessive drive at the end of the month, added $2,220 (first line) to the power bill of that month. It is doubtful if the increase in output added $2,220 to the profits of the plant for that particular day. Note in the second line how 1½ hr. added $2,433 to the demand charge of that month, and in the third line how 2¼ hr. added $3,105 to the demand



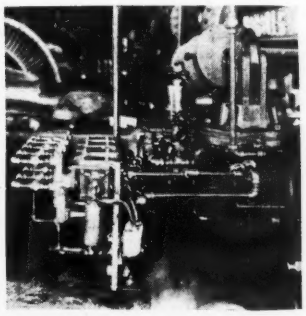


Fig. 3 (Left)—Master controller can be set to keep the load within a predetermined maximum demand automatically. Fig. 4—Four-stage magnetic unloader on an air compressor

charge. For the fourth line, one day added $2,430, and in the fifth line, 6 hr. added $5,130, and it might be said that the entire amount was added in 1¼ hr. Spotty production is shown in the sixth line where $4,725 was added to the demand charges as a result. The load-control device would cost about $5,000, and it seems to offer a rather handsome return on the investment."

It is evident that control of maximum demand presents a real opportunity for reducing power cost to industrial plants. To provide this control, the Edmoore Power-Demand Limitator was developed automatically to eliminate demand peaks above a predetermined value. This equipment is connected to the incoming power lines through metering transformers, in a similar manner to a wattmeter. It is also connected to some part of the load that can be temporarily reduced without interfering with production.

The demand Limitator is set for the desired maximum demand. When the total demand reaches this setting, the controller functions automatically to keep it within the predetermined maximum. These reductions of load are never of long duration, rarely more than one minute and frequently less than that. Usually there is no interference with production, sometimes a slight interruption is allowed that is more than compensated for by savings in demand charges. The following gives some typical examples of how maximum demand is controlled automatically.

Unloading air compressors is one of the common methods of controlling maximum demand. One of the large compressor manufacturers has on several occasions supplied Limitators as regular equipment with compressors.

The usual arrangement is to use a master controller, Fig. 3, the load dial of which may be set for a predetermined plant load level. By unloading and reloading

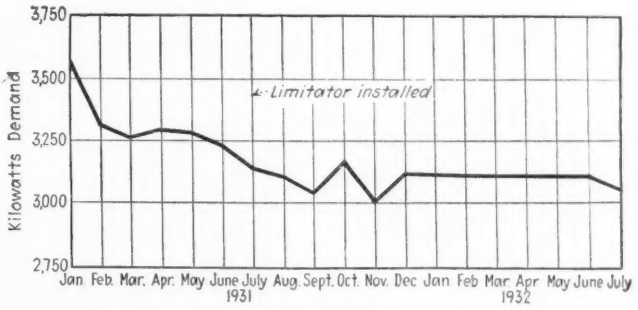


Fig. 5—Monthly power demand curve of a large mine load

one or more air compressors, the load is prevented from exceeding the set demand.

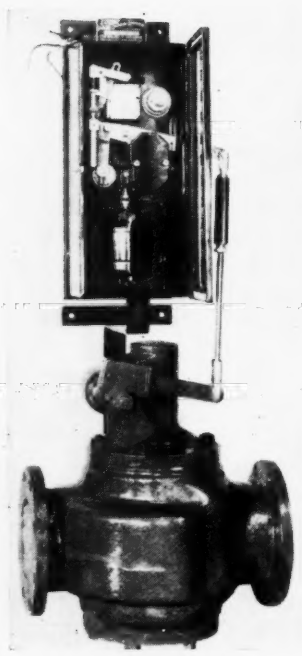
With this type of load control the unloading intervals may be a fraction of a minute only. Although several unloading periods may occur during a given demand interval, such as 15 min., the air pressure will not drop low enough to interfere with operations, since the compressor between unloading periods has an opportunity to build the air pressure up to normal.

Where desired, a minimum-pressure mechanism may be incorporated with the automatic demand-control device to guard the pressure against becoming unduly low, by reloading the compressor if the air pressure falls below a safe value. Under these conditions of reloading, other selected equipment in the plant is then unloaded for the required interval.

Under some conditions, particularly where there is ample air-storage capacity, the integrated method of control may be used. By this arrangement unloading periods will be less frequent, under like conditions, but of slightly longer durations.

The main element of the demand Limitator may be equipped with any desired number of load-setting dials so that several compressors may be unloaded in sequence at different load values. If individual compressor unloaders are of the multi-stage type, the stages may be unloaded in sequence. In Fig. 4 is shown a four-stage magnetic unloader used to automatically and progressively load and unload the compressor according to the load on the plant's main incoming power supply.

The curve, Fig. 5, shows what was accomplished by automatically controlling the mining-load power demand of the El Potosi Mining Co., Chihuahua, Chih., Mexico. Power is supplied to the property from five different sources and is totalized. The demand is controlled by automatically unloading and reloading four air compressors and in case of extreme peaks an 800-hp. hoist motor is tripped off the system. On Aug. 5, 1932, mining operations were curtailed, consequently data is not available since that time. During the period that automatic control of maximum demand was in service, it is



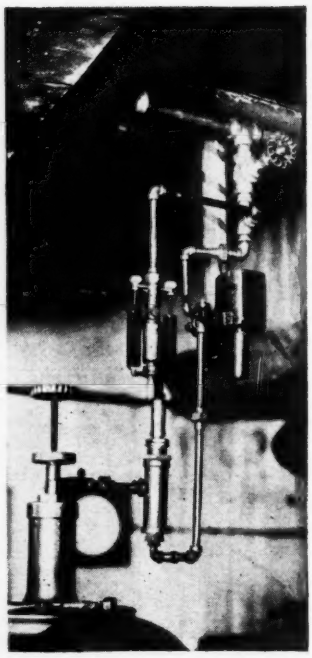


Fig. 6 (Left)—Motor-operated pressure-water governor valve. Fig. 7—Single-stage magnetic unloader on large air compressor

estimated that a saving of from $500 to $1,000 per month resulted, based on the previous method of operation.

Power for the Gilman Paper Co., Gilman, Vt., is purchased on a flat demand basis without an energy charge. To keep power cost at a minimum it is therefore imperative that as many kilowatt-hours as possible be used for a given demand. The kilowatt element of the demand Limitator is arranged to actuate a motor-operated governor valve, Fig. 6, in the pressure-water line to two pulp-wood grinders. When the total load is abnormal the demand controller functions to cause the governor valve to close sufficiently to reduce the hydraulic pressure and partly to unload the grinders. When the total load is subnormal the governor valve increases the load on the grinder motors. Thus the demand controller functions to reduce peaks and fill up the valleys of the load curve, and maintains the load factor at over 97 per cent.

Most coal mines have peak-load demands that can be controlled without causing loss of production. In some mines the demand-limiting device gives a signal to the miners at the coal cutters to temporarily cease operations and shortly after this the tipple load is cut off. At another mine, if the coal cutters do not cease operations when signaled and the load builds up to a second predetermined value, the locomotive power circuit is interrupted automatically. These temporary curtailments, while ample to limit the demand, are not of sufficient duration to curtail production or seriously interfere with operations. Operators of one mine report a saving of $2,500 per year in power costs by controlling demand.

Installations in the rubber, cement, and other industries have shown that it is possible to control maximum demand under a wide variety of conditions and make large saving in power costs.

Where it is desired to know what the saving is each month, a demand recorder is available that functions only when the power supply is interrupted. If there are ten load interruptions per month, there will be ten lines on the chart, from which the reduction in kilowatt load and the saving in power cost can be determined.

BENSON BOILER TO OPERATE AT ALL PRESSURES

WHEN first introduced, and for some years after, the Benson boiler was used exclusively to generate steam at the critical pressure of 3,200 lb. or higher. At such pressures water turns into steam without boiling, passing quietly from one state to the other, at the proper point of the forced-circulation tube of the generator.

The Benson boiler is now coming into a striking new stage of development, according to news received recently from Messrs. Siemens-Schuckertwerke, Berlin, Germany, reporting a lecture recently delivered by Mr. Gleichmann of that organization.

According to Mr. Gleichmann, the Benson boiler can now be satisfactorily operated at all pressures from 1,000 lb. up. Formerly, where steam pressures of less than 3,200 lb. were desired for turbine or engine operation, the Benson generator was still operated at 3,200 lb. and the steam then passed through a reducing valve. The new development eliminates the waste resulting from the former feed-pump pressure.

According to Mr. Gleichmann, the difficulties formerly observed in flow through forced-circulation boilers are not caused by the boiling, as was thought, but by the deposit of salts in the portion of the tube exposed to high gas temperatures. By redesigning the boiler, the zone of salt deposit can be lifted to a point where gas temperatures are low and burnouts will not occur. In addition, of course, an efficient method of blowdown is required, and this Siemens-Schuckertwerke seems to have developed.

In the future, according to Mr. Gleichmann, the Benson boiler with critical pressure will be used in all cases where large units and high load factors call for maximum efficiency. In all other cases, however, where low turbine pressures are chosen, the Benson boiler will be operated at correspondingly lower pressures. It is claimed that the under-critical Benson boiler can replace not only other tubular boilers, but also drum boilers.

Based on the newly discovered possibility of operating safely below the critical pressure, Messrs. Siemens-Schuckerwerke have developed a new method of boiler and turbine operation, the feature of which is the omission of the control throttle pressure. The proposal is to operate the turbine with the maximum pressure at maximum load and let the pressure adjust itself automatically at partial loads, the boiler output being adjusted according to the turbine load. An advantage is the saving in feed pump work at times when the higher pressures are not required.

A detailed project has been worked out by Siemens-Schuckertwerke for a peak-load central station with 500-lb. normal and 2,000-lb. peak pressure, giving a turbine output from 5,000 kw. to 20,000 kw. The operating advantages of such a plant working with variable pressures are claimed to be enormous, and the first costs referred to maximum capacity surprisingly low.

WELDED-STEEL DIESEL ENGINES

By EVERETT CHAPMAN*
Vice-president in Charge of Engineering, Lukenweld, Inc., Division of Lukens Steel

Crank cases and small parts of welded steel have recently been introduced in this country and in Europe. Here the author describes development work on the new Winton welded-steel diesels

A GREAT deal of the weight of a diesel is in the crankcase. Combination of high pressures and large piston diameters results in large loads. The strict requirement of structural rigidity and the fatigue nature of the load demand that the usual cast material be worked at low stresses, which results in the excessive weight figures (40-250 lb. per hp.) that are usual practice today. The tension nature of the load, imposed on a material not well suited to tension loading, results in a composite structure consisting of steel tie rods connecting the main bearings with the cylinder heads. These rods are in turn surrounded by a cast iron structure which supplies the necessary rigidity for minimizing vertical deflection due to the gas loads and the horizontal components resulting from the inertia loading of the crank pins and rods.

The first step in the reduction of the weight of the usual arrangement naturally contemplates the use of steel instead of cast iron. Many attempts have been made to execute the lightweight diesel crankcase in cast steel. But here again is an inhibiting factor, cast steel will not flow in sections as thin as cast iron.

The only alternative, then, is the use of rolled steel plates and shapes to build up the desired structure. To join the components, riveting is out of the question because the non-homogeneous and semi-rigid joints will not stand up under this severe service. In contrast, welding is eminently suited as the method of fabricating the rolled steel crankcase.

Questions on the application of welding to diesel engine crankcases center about two prime requisites, stiffness and endurance life, plus a secondary factor—corrosion-resistance—which affects only those marine installations where salt water is used as a cooling medium.

Questions concerning structural rigidity are answered by the fact that steel is the stiffest commercial material known to man. Further, the flexibility of the welding process enables the designer to use economical, efficient sections that have been impractical in other manufacturing methods. Thus, the matter of requisite rigidity is controlled entirely by the designing department.

The problem of endurance life can be rather simply stated, although the subject as a whole is somewhat involved. The essence of the matter is that the stress range through which the component materials can be repeatedly stressed indefinitely without causing failure must be known. The maximum stress in the structure, wherever it occurs, must be under the known safe value. A low average stress as usually calculated cannot possibly guarantee an indefinite service life, it is the maximum stress which governs. A point of maximum stress may lurk in a hidden corner with too sharp a radius. It may exist in the bottoms of small tool marks. It may be present at undercuts unconsciously made during the welding process. It may be found at any small blow-holes or porosity in the materials. In particular, in the welding process, points of maximum stress always exist around an improperly designed welded joint. In an otherwise perfect design satisfying the rigidity requirements for succesful functioning of the engine, the only thing that will break the structure subjected to repeated load is the existence of a hidden, minute defect in contour which multiples the average stress condition by a factor of 5, 6, or even more. Points of high local stress are evident only as fatigue failures. Such points of high stress occur over such small areas that they have no influence on rigidity. Ductility cannot operate to alleviate a high stress condition as it does in statically-loaded structures, since this phenomenon requires a permanent deformation which is inadmissible in a crankcase that must preserve main bearing alignment.

An alloy steel which has been found

*An abstract of a paper before the Oil & Gas Power Division A.S.M.E., Atlantic City Meeting, Aug. 23.

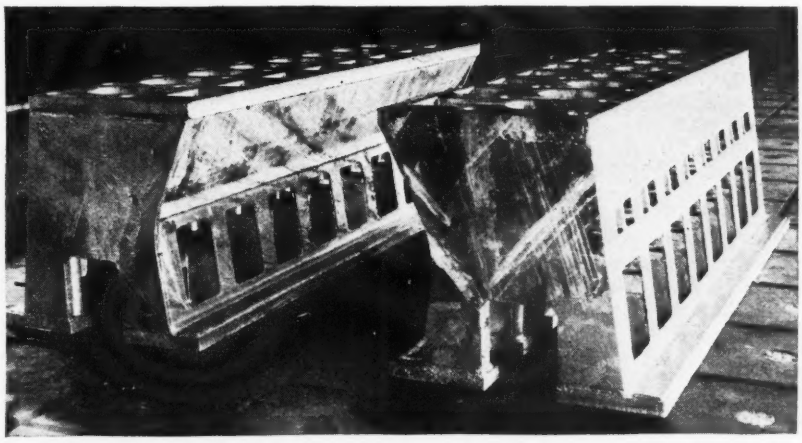


Fig. 1—Two 500-hp., 4-cycle marine engine crankcases with galvanized water jackets

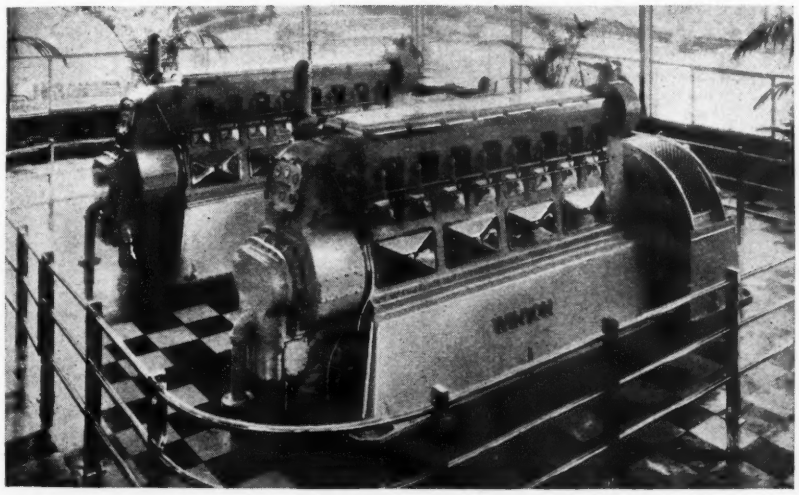


Fig. 2—Two Winton 2-cycle, welded-steel diesels supplying power and light to the General Motors Building, Century of Progress

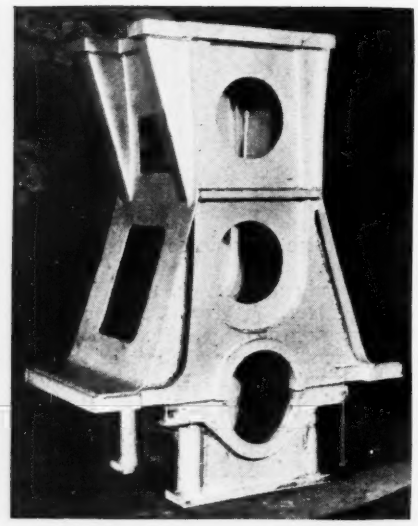


Fig. 3—Built-up single-cylinder test unit

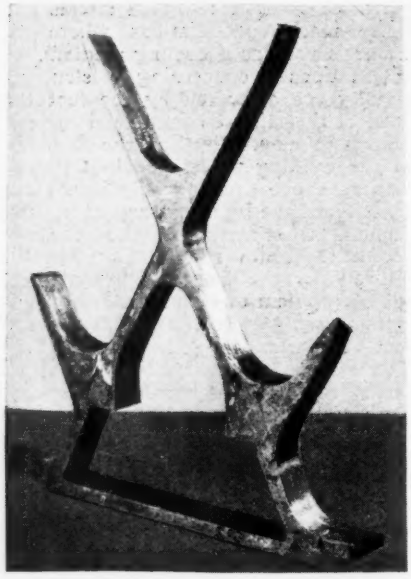


Fig. 4—Flame-cut main frame for 1,000-hp. twin-six engine

most applicable to welded steel crankcases is of low carbon content and, therefore, well suited for welding. Its endurance limit is 50,000 lb. per sq.in., as contrasted with 30,000 lb. per sq.in. for ordinary mild steel plate. A definite limiting range of stress at which the material will function for an indefinitely large number of reversals has been proved to exist for all materials. If the engine is not to fail prematurely but is to serve indefinitely, the product of the average working stress and the stress concentration factors (always introduced during fabrication) must not exceed this safe stress range—50,000 lb. per sq.in. in this case.

Stress factors of almost any magnitude can exist in a structure. A round hole in a body of material will raise the stress in its locality by a factor of 2.7. A round hole on the surface of a material will raise the stress three times. These factors are not serious, since the demands of rigidity will call for average stresses which, when multiplied by these factors, will not constitute a source of worry. The serious type of stress concentrations, against which the designer must guard diligently, are those exemplified by sharp corners and re-entrant angles. Mathematically, the stress concentration factor which exists at a corner or re-entrant angle is inversely proportional to the radius of curvature of the corner. There are many types of welded joints in which the radius is nearer zero (corresponding to infinite stress) than can ever be approached by machining. Concentrations of this nature cannot be tolerated.

Other points to be considered are the condition of the weld, the endurance value of the weld metal, and the damage to the base metal by the high temperature of the welding operation. This poor condition is corrected by heat-treatment of the welded structure after completion of all welding. Heat-treatment also removes the residual stresses in the structure. These may reach 30,000 lb. per sq.in., which is nearly the yield point of ordinary material. If the structure is unfortunately loaded in the same direction as the residual stresses, there is no apparent strength.

The other important phase of stress relief is that an unannealed welded structure will exhibit unseasoned properties worse than the greenest casting ever encountered. It will warp and twist on the planer and boring mill to a degree that will render the structure useless. It will not hold its shape over any period of time. A multiplication of difficulties occurs at the edge of the weld where the metallurgical damage coincides with the severe discontinuities in weld contours.

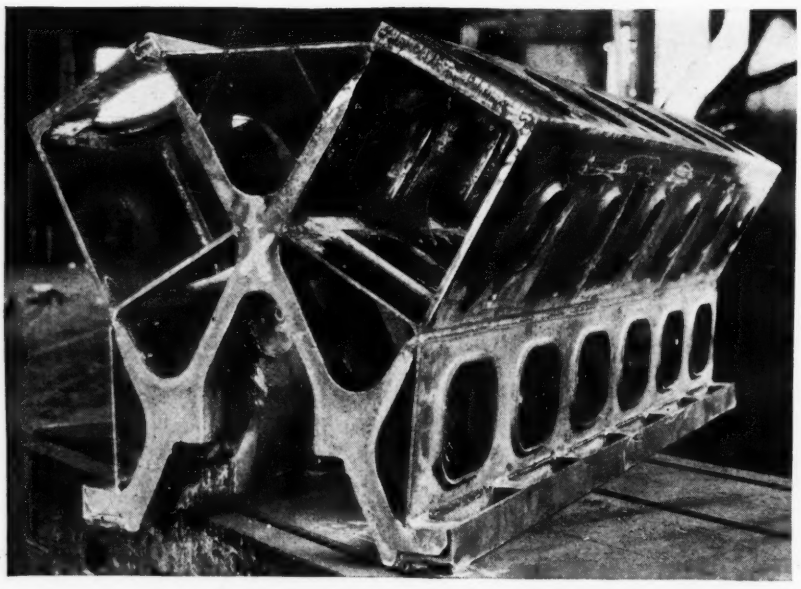
The general subject of corrosion resistance of the weldable materials can be amply covered by the statement that there are many weldable materials with remarkable resistance to salt water corrosion. The admirable record of wrought iron hulls in salt water could be duplicated in the water jacket of a welded-steel crankcase. The stainless steels, nickel-clad steel and other clad metals, are all possibilities. Two of the early welded engines were galvanized in the region of the water jackets and a 2-year record in salt-water service has shown them to be entirely adequate. Fig. 1 shows two 500-hp., 4-cycle, marine engine crankcases with galvanized water jackets.

The engines shown in Fig. 1 were built of low-carbon, welding-quality steel with endurance values for an indefinitely repeated stress of 30,000 lb. per sq.in. The weld metal used to join the components had an endurance limit of 28,000 lb. per sq.in. established by rotating beam test on all-weld metal specimens. It was then a matter of eliminating all undercuts, unfused welded joints, and surface discontinuities of any type, since it is easy, at an average stress of 5,000 lb. per sq.in., to incorporate a stress factor of 5 or 6, which would legislate against indefinite service life. The crankcases weigh about 5 lb. per hp.

Fig. 2 shows an installation of the same general type of crankcase, with the exception that the engine is two-cycle and slight modifications were made to take care of this feature. These engines form part of the Winton Engine Corporation's exhibit at the Century of Progress in Chicago, and have been in continuous operation since the opening of the Fair, supplying power and light to the General Motors Building. This installation, including generator and subbase, has a specific weight ratio of 39 lb. per hp. The specific weight ratio of the engine itself is 20 lb. per hp.

To eliminate still more weight in steel crankcases, the construction of a case was initiated, in which the gas and inertia loads were carried entirely by the welded structure. With the tie-rod type of construction, much material is not working effectively, especially if the tie rods are not set properly. In a completely welded unit, better distribution of the stresses can be achieved because of the monolithic construction. An experimental single-cylinder frame was built, embodying a main frame flame-cut from a plate of steel 2 in. thick. This model was subjected to strain gage tests to determine the efficacy of the conception. Fig. 3 shows the built-up single-cylinder unit. The main frame was joined by welding to the top deck, into which the cylinder-head studs were

Fig. 5—Crankcase partially completed



tapped. This frame showed satisfactory deflection and stress characteristics.

An effective method of determining points of maximum stress in a three-dimensional structure is to paint it with a varnish possessing a low modulus of elasticity and a low yield point. When a static load is applied to the structure, the varnish cracks at the point of maximum stress while the structure is only lightly loaded.

Based upon this experiment, construction was undertaken of a 1,000-hp. twin-six engine, in which the entire gas load was carried by the welds. Fig. 4 shows the type of flame-cut main frame used. This frame transmits the gas load of one bank of cylinders past the gas load of the other bank of cylinders, and into the main bearings. The minimum weight design is one in which the material is loaded in straight tension. The flexibility of flame-cut steel plate in meeting this ideal condition is well illustrated by the frame member of Fig. 4. The stub ends of the frame could not be run through to the top deck because the stagger of the connecting rods produced a 3-in. offset in each cylinder with respect to the cylinder in the other bank, which necessitated the use of a transition joint. Since the transition joint had a peculiar shape, more experimental work

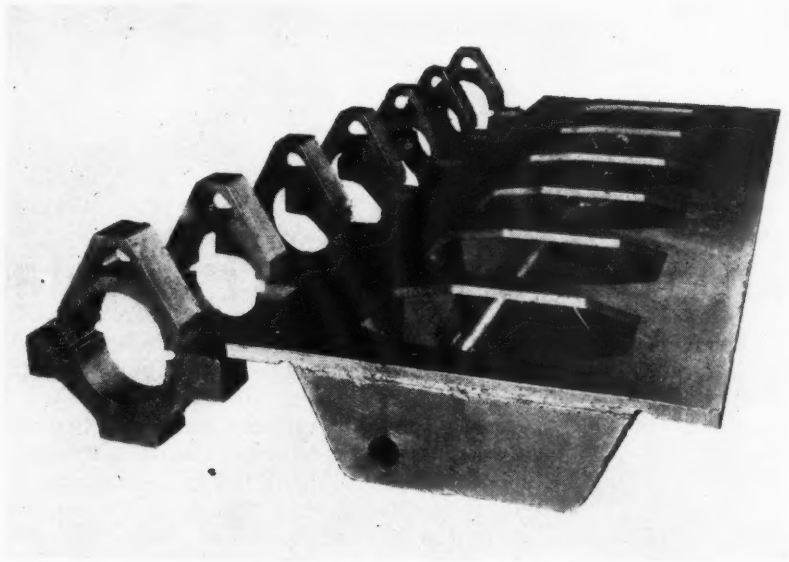


Fig. 6—Main bearing caps and oil pan

was done to determine an efficient design for the joint before proceeding with the engine. Stubs were inserted in the notched plate and welded strictly in accordance with photo-elastic studies. The experimental joint simulated the condition in the engine where the joint carries an impact load of 19,000 lb. The joint tested fractured outside the weld, through the plate, at a load of 212,000 lb. Tensile tests of such joints in conjunction with a coat of brittle varnish are very instructive.

The top deck of the crankcase was welded to the transition plate with a single butt weld running the entire length of the engine on each side. The gas load of each cylinder is then carried through the butt weld at the top deck, and through the two transition joints to the main bearings. Each weld, including the transition joints, was radiographed by means of radium to discover any imperfections, unfused joints or porosity that might have existed. The crankcase was also thoroughly inspected for undercuts and surface discontinuities.

Fig. 5 shows a stage in the progress of the crankcase. The inner deck which carries the lower end of the cylinder liner is in place. The side plates and stiffening ribs have been added. The hand holes providing access to the connecting rod caps and the hand holes for inspecting the piston rings have been flanged in the side plate itself. In welded steel construction, there is a tendency to use thin sections because of the strength of the material. It is necessary to guard against unsupported areas of any magnitude in thin material when the mechanism is one which may set such areas in resonant vibration. The flued hand holes stiffen the thin plates admirably against this phenomenon.

Fig. 6 shows the main bearing caps and oil pan. The main bearing girders are flame-cut from 4-in. steel plate. The oil pan was constructed as shown to provide a tie for the bottom legs of the main frame members. Fig. 7 shows the completed crankcase as it left the weld shop, with the crankcase mounted on the oil pan to illustrate the manner in which the oil pan forms the bottom tie for the complete case.

Built in the high-strength, welding quality alloy steel, this crankcase has a

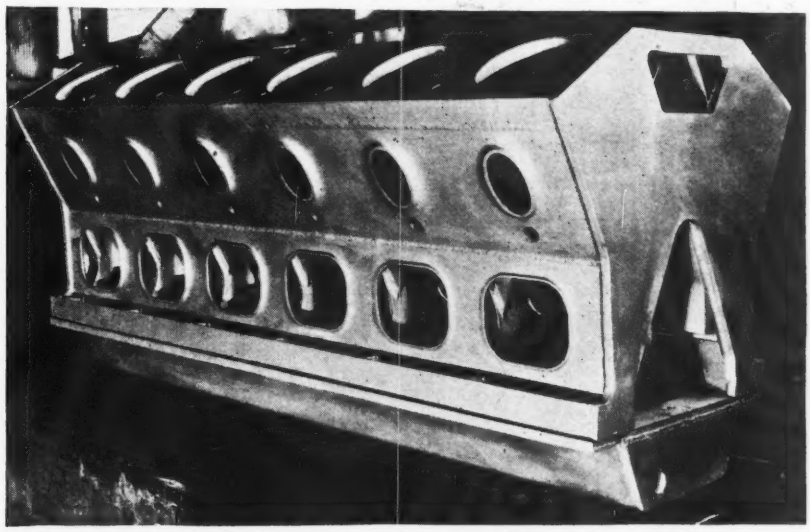


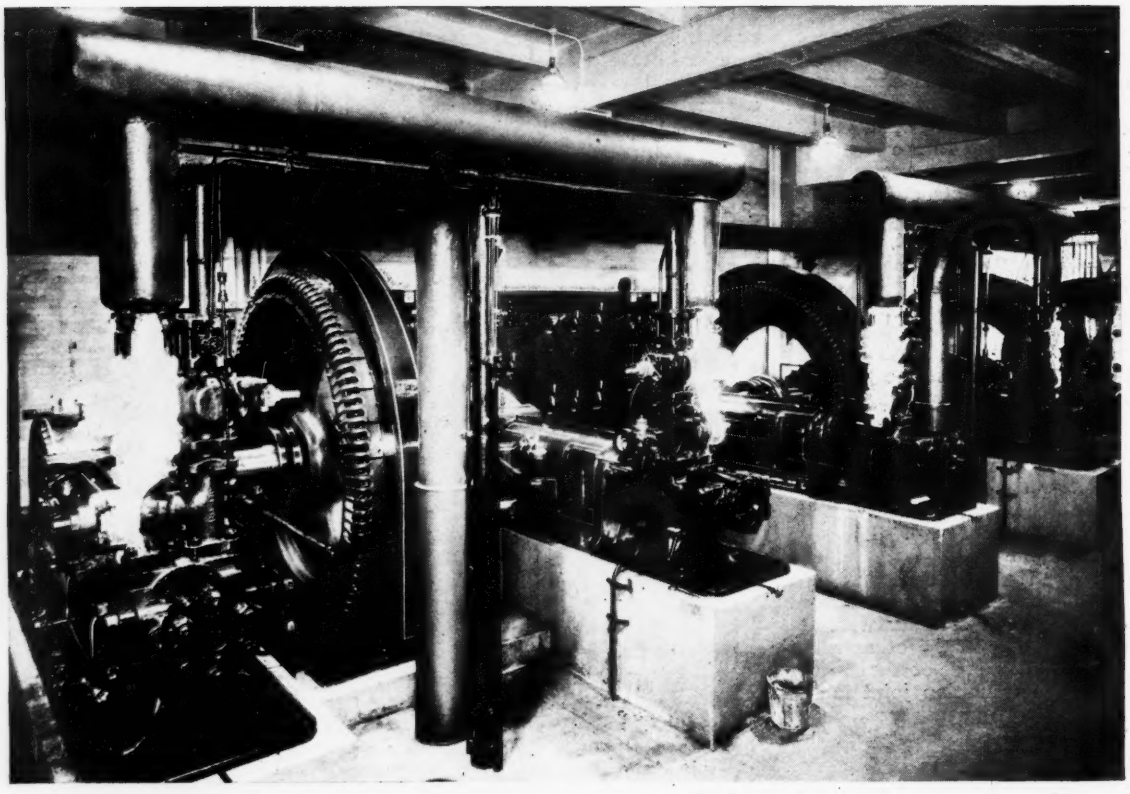
Fig. 7—Completed crankcase

weight of about 2.6 lb. per hp. The entire engine weighs less than 10 lb. per hp. running on the test block. Calculated from the indicator card, each weld in this structure is subjected to an impact load of 38,000 lb., occurring twelve times each second. A recently completed 300-hour full-load run indicates that the frame has been subjected to a number of cycles of stress far beyond that necessary to establish the fact that the stress concentrations which undoubtedly exist in the frame are not large enough to raise the average stress above the endurance limit for the alloy steel from which the frame is made.

The performance of this welded-steel crankcase offers conclusive proof that welded joints can be designed and constructed commercially to handle, at a high stress, the most severe type of load encountered in modern mechanical practice—that of repeated impact.

A radial engine crankcase has been welded of plate and steel castings which weighs less than 1 lb. per hp.

Welded steel crankcases of the types discussed enable the engine builder to offer to the user of mobile prime movers a light-weight, highly efficient and powerful unit, embodying all the advantages of the diesel principle. Winton Engine Corporation of Cleveland, with which it has been a privilege to work in this development, can offer today an engine-generator unit supplying 750 kw. of electrical energy which, including all auxiliaries, will weigh 30 lb. per hp. Railroad vision has enabled immediate application of this notable prime mover to main line service. Under construction today is a welded-steel engine structure which will be used in the power unit of the Union Pacific System's 110-mile per hour high-speed passenger train. The Chicago, Burlington & Quincy's high-speed passenger train will have, as its motive power, a 600-hp. diesel engine of welded steel construction.



Four CO_2 compressors supply 300 tons of refrigeration

300-TON Refrigeration Plant for New York Hospital

By W. H. FISHER
Mechanical Construction Superintendent

THE New York Hospital-Cornell University Medical College is one of the country's largest. It has capacity for 1,000 bed patients and 1,000 out patients per day and has a working population of about 3,000. Every effort has been made to further the comfort of its patients. In this, refrigeration plays an important part.

Refrigeration requirements are supplied from a 300-ton, carbon-dioxide, compression-refrigeration plant in the power house (described in the August number of *Power*), and comes directly under the supervision of the power engineer. From it refrigerated brine is circulated to the hospital and college buildings, supplying refrigeration for kitchen and restaurant purposes, the hospital morgue, cooling rooms where experimental animals are kept, and for air conditioning. Brine for air conditioning is supplied to three Baudelot coolers and two shell-and-tube coolers in which the water used in the air washers is cooled to the temperature required for proper air conditioning. Drinking water is chilled in brine-coil and tank coolers in the hospital and power plant basements. In addition to the refrigeration supplied from the central plant, there are numerous small electrically operated refrigerators throughout the hospital, used for medical purposes.

The refrigerating equipment is located in a court in the power house, the axis of the compressor room being parallel to the engine room but raised above it about 6 ft. As in the engine room, the walls are finished with white vitrefied tile, but the floor is red cement instead of tile.

There are two 2-cylinder Brunswick-Kroeshell CO_2 compressors of 100-ton capacity each, and two single-cylinder units of 50-ton capacity, making a total of 300 tons of refrigeration. All of the cylinders have $5\frac{1}{2}$-in. bore and 15-in. stroke, thus decreasing the number of spare parts that need be carried in stock. The 100-ton machines are driven by 200-hp., 138-r.p.m., 550-volt synchronous motors, and the 50-ton machines are driven by 100-hp. synchronous motors of the same type. The size and number of compressors installed makes it possible to balance quite closely the compressor capacity and refrigeration load.

Each compressor cylinder is provided with a mercury switch arranged so that it will shut the machine down in case the discharge pressure goes above 1,250 lb. Space has been allowed in the compressor room for a future 100-ton capacity machine.

Along the wall at the crank end of the compressor is a switchboard and a gage board containing indicating gages for discharge suction and stuffing-box pressures on each of the CO_2 compressors, gages showing the general brine pressure, the brine pressure to the ice tank and ice storage rooms and inlet and outlet water pressures through the CO_2 condensers.

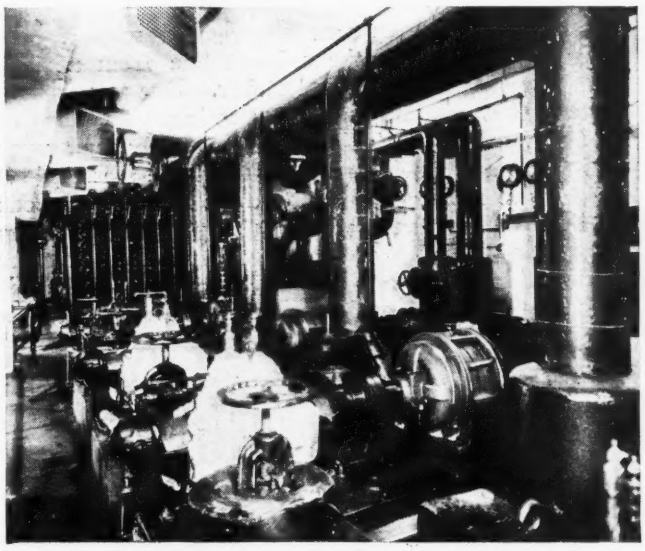
Along the opposite side of the compressor aisle, the floor is raised some 3 or 4 ft., and at one end of it is

the CO_2 condenser, which is of the horizontal multi-tube type. The condenser has capacity to handle the ultimate compressor capacity of 400 tons. It consists of eight stands with seven sections in each stand.

Carbon dioxide discharged from the compressors is delivered to the condenser through three welded pipelines. The two smaller units deliver into a single line, whereas the larger unit delivers to the condenser through separate headers. With this arrangement, a leak in the high-pressure CO_2 piping can at the most decrease the plant capacity by only 100 tons.

City water is used for condensing, and is discharged to the surge tank in the basement, from which it is pumped and used for domestic purposes throughout the hospital. The condensing water circuit is arranged and valved so that the condensers can be back-washed for cleaning purposes. During the summer, the temperature of the water entering the condensers is about 74 deg. and it discharges at about 84 deg. This gives a head pressure of about 1,028 lb. sq.in. at the compressor discharge.

The condenser in the background has been installed for the future 400-ton capacity



Condensed CO_2 is collected in a 4-in. header which acts as a refrigerant receiver. The refrigerant is delivered to two brine coolers housed in a separate room on the same level as the condensers and insulated with 4 in. of cork to improve the efficiency of the coolers. The larger brine cooler is used for general purposes in the hospital, the smaller being used for cooling brine for ice-making. Brine coolers are arranged in two banks on opposite sides of a central aisle. Each bank for general-brine cooling has fourteen stands 3 sections high. Each bank for ice-brine cooling has four stands.

Four pumps located in the raised portion of the refrigerating room are provided for circulating brine for general use in the hospital. Three of these pumps have a capacity of 450 g.p.m. and are driven by 30-hp. motors. One pump has a capacity of 300 g.p.m. and is driven by a 20-hp. motor. Normally, two 450-gal. pumps operate.

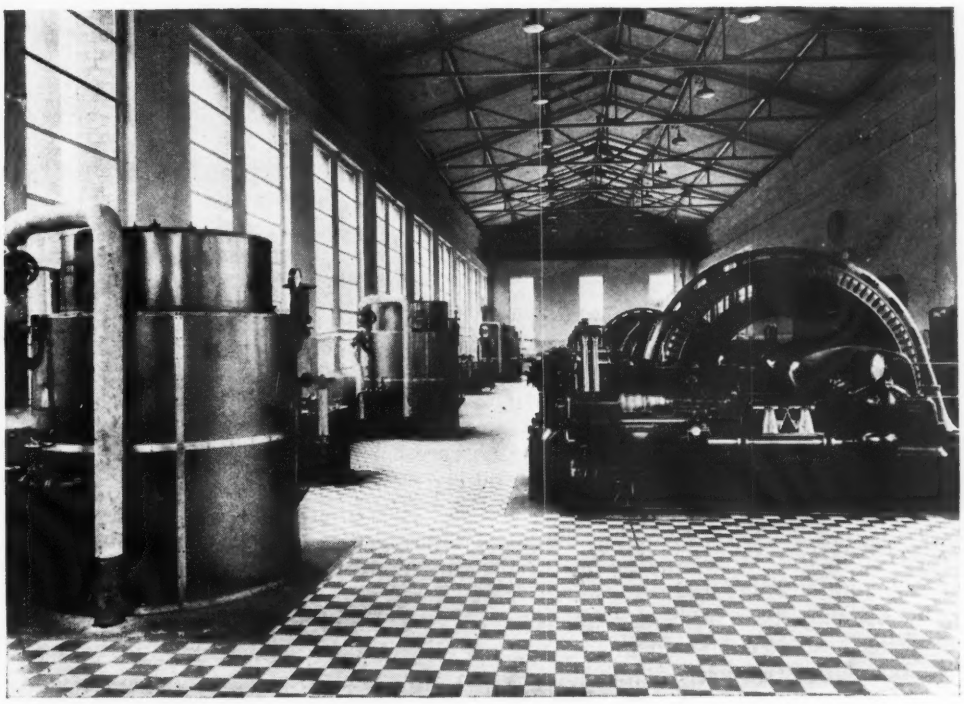
Brine circulation for ice making is provided by two 200-g.p.m. pumps, each driven by a 5-hp. motor. The two brine systems are entirely separated, the brine for ice making also being used for cooling drinking water for the power plant and nurses' home. In both systems, strainers have been provided both on the inlet and discharge side of the pumps. An extra heavy brine suction tank of 1,000 gal. capacity is located in the sub-basement near the boiler feed pumps.

During the summer months, the general brine is carried at about zero deg. temperature. Brine for ice making is carried at 14 to 18 deg.

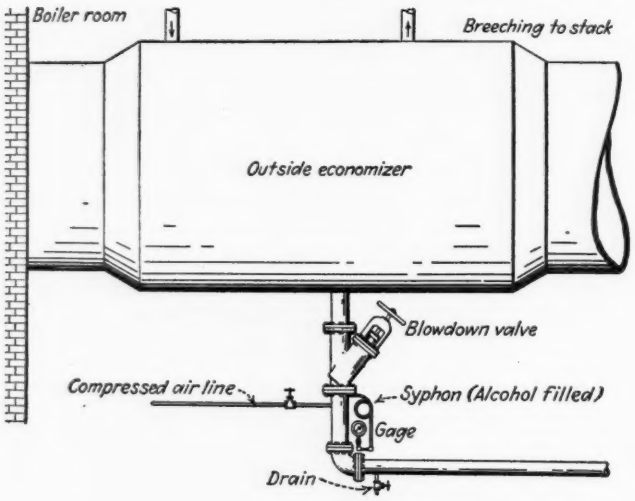
The brine for ice making is discharged through nozzles at one end of an ice tank. The brine circulates past 153 50-lb. cans. These are arranged so that three cans are dumped at a time. No air agitation has been installed, as it is not necessary to produce clear ice. Two ice storage rooms have been provided, one for cracked ice and the other for the ice as received from the cans.

GAS ENGINE SUPPLIES ELECTRICITY, STEAM AND HOT WATER

Schwelmer Iron Works, Westphalia, Germany, has this 2,300-hp. Deutz gas-engine plant equipped with waste-heat boilers. Two 700-hp. engines and a 200-hp. (peak load) unit supply a.c., the remaining 700-hp. unit drives a 60-volt d.c. generator. Without credit for exhaust-heat recovery, the plant consumes 15,000 B.t.u. in coal per kw.-hr. Waste heat credit reduces this figure to 9,000 B.t.u. Producer efficiency is 78 per cent. Of the heat in the gas, 29 per cent is delivered as electricity, 34 per cent as hot water and 17 per cent as steam at 85 lb. pressure. Only 20 per cent is wasted.



PRACTICAL AIDS TO OPERATION



Protecting Outside Economizer Blowdown Line

THIS outdoor economizer was installed in a northern New England plant where severe winters are prevalent. Freezing of the blowdown line during cold weather after the economizer had been blown down caused considerable trouble. To prevent this trouble, a ½-in. line was extended from the plant compressed-air system to the economizer and tapped in to the blowdown line just below the blowdown valve. After blowing down, air pressure was turned on until the line was blown clear. This was indicated by a sudden drop in the pressure shown by the gage. Alcohol was used to fill the gage line and syphon to prevent freezing of the parts.

As further protection against freezing because of possible leakage through the blowdown valve, a drain valve was installed. This drain was opened after the air pressure was shut off to show if the blowdown valve was tight.

Milford, N. J. HARRY M. SPRING.

Detecting Oil in Boiler

ABOUT a year ago, I became superintendent of a textile mill which used condensed steam from the exhaust of a cross-compound Corliss engine as feed water. A little make-up feed water comes from the city supply.

A month after I took charge, the mill was shut down as my observations made me believe that the water in the boiler had too much oil. I made my observations at the water level in the gage glasses. The oil layer on top of the water level in the gage glasses and the time required before such layer accumulates after blowing off the gage glass cocks are indications of the condition of the water in the boiler and naturally of the feed water.

On opening the feedwater filtering equipment, I found that the filter medium was soaked and clogged up with oil. Investigation of the boiler room personnel revealed that the former engineer had not opened the filter for more than six months.

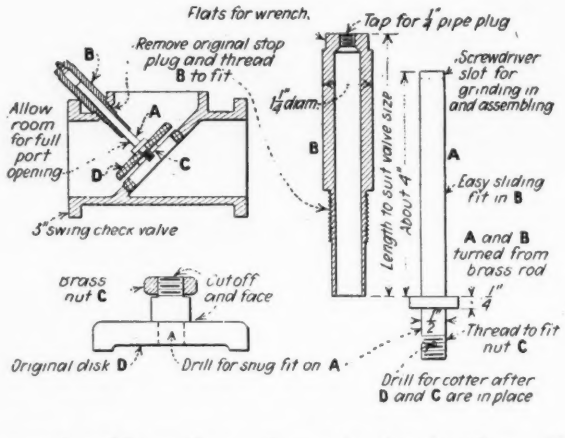
After the boiler had been cleaned properly, I gave orders to open and change the filter medium of the equipment every Sunday morning. This simple routine work of about two hours has kept the boiler in good working condition and the feed water practically free from oil up to date. DOMINGO S. MENDOZA

Manila, Philippine Islands

Rebuilt Check Valve to Stop Wear of Disk and Seat

CONSIDERABLE trouble was experienced with a 3-in. swing check valve in the exhaust line from a small turbine driving an underfeed stoker. Due to variation of steam flow caused by governor action, a fluttering of the disk was set up. This caused extremely rapid wear of the seat and moving parts of the valve that made it necessary to replace them every three months. On one occasion, the disk came loose and lodged squarely across the outlet of the valve, causing an excessive back pressure on the turbine.

The disk carrier and hinge pin were removed and a


Flats for wrench.
Tap for ¼" pipe plug
Remove original stop plug and thread B to fit
Screwdriver slot for grinding in and assembling
Allow room for full port opening
1" dia.
Length to suit valve size
About 4"
Easy sliding fit in B
3" swing check valve
A and B turned from brass rod
Brass nut C
Cut off and face
Thread to fit nut C
Original disk D
Drill for snug fit on A
Drill for cotter after D and C are in place

stem and guide made as shown in the drawing. With this construction, the impact of the disk is uniformly distributed on the seat, and apparently some dashpot action is obtained from the valve stem in its guide. The change was inexpensive to make, and after nearly a year's service the valve shows very little wear and its operation has been greatly improved.

H. A. PIETZNER

Evansville, Ind.

How Coal Quality May Change

BUYING the proper coal and its most efficient use is not an easy problem as is appreciated by the majority of power engineers. The intermediate steps between purchasing and burning the coal frequently defeat the most intelligent efforts of the purchasing agent and the boiler operator. A representative sample is carefully selected

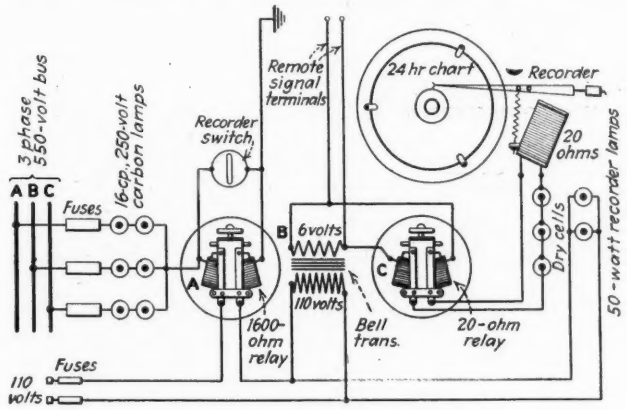
to judge the coal by analysis, but when the coal is delivered at many plants, successive handling operations tend to destroy its homogeneous character. When taken from the bunkers, the fine or coarse grades are frequently separated. Absence of surface moisture increases this tendency to segregate.

The coarse coal can be burned with less draft and excess air, but the furnace temperature and clinker troubles increase. The fines decrease the combustion rate, and the combustible losses in the flue gas and to the ashpit increase. Unsatisfactory operation not anticipated when the coal is selected may be the result.

Kingston, Ont. T. J. DONNELLY.

Sensitive Ground Recorder for Low-Voltage Systems

AT OUR PLANT, a large number of motors are installed. It was felt that the lamp ground detector was not sufficiently sensitive to warn of impending trouble. A new ground detector and recorder was therefore installed. While it can be constructed by the average mechanic, it



is sensitive and will detect and record all current leakage on the system to which it is connected.

The detector uses 250-volt, 16-candlepower, carbon lamps, two in series, star connected, with a 1-amp. fuse in each line. Other combinations of lamps may be used, depending on the line voltage of the system. The star point is connected to a permanent ground through a sensitive relay *A*, so connected that current leakage to ground will flow through its coil.

When this relay closes, an auxiliary 110-volt circuit is completed through its contacts. This in turn energizes a small bell transformer *B* and also lights the 50-watt bulbs in the recorder, which illuminates the chart.

The transformer secondary-circuit current operates a second relay *C* which closes the recorder circuit, energizing its coil, which in turn attracts the armature to which is connected the pen arm. The pen is drawn across the chart, recording the time and duration of the current leak. Terminals are provided for a remote signal gong or pilot light to operate simultaneously with the recorder. The recorder switch is used to bridge the recorder when it is desired to use the detector only. The instrument is installed in the electrical shop where it is at all times in view of the man on duty. The recorder does not normally measure the current leakage but records the time and duration only. Provision is made to insert a recording ammeter if it is desired to study the behavior of any particular effect.

A portable detector on the same principle, but without the recording chart, mounted in a hardwood box with a carrying handle and 20 ft. of extension cord with insulated clips at the ends was constructed to locate trouble on the distribution lines.

Immediately a ground is noticed on the recorder, all feeders that can be dropped out without serious inconvenience to production are opened and reclosed. If the fault is not located on any of these, the more important feeders are opened at noon or when work is finished for the day. When the feeder on which the fault has developed is found, a man starts out with the portable detector and traces down the trouble by opening the sub-circuits while the portable is clipped on the line. In this way the ground is quickly found, and the faulty equipment can be taken out of service and repaired.

ELLIS MILLS

Toronto, Ont.

Leaks Inside and Not Outside the Orsat

WHAT appear to be leaks in the Orsat apparatus for analyzing flue gas may not be. This was found to be true recently in a portable Orsat. The apparatus developed what seemed to be a persistent leak in the CO or cuprous-chloride bottle. All the connections were refitted with new rubber gaskets and thoroughly shellacked in an effort to stop the leak. Finally, in an attempt to find the hole, the liquid in the bottle was put under pressure. It was found that the leak was really a formation of gas inside the bottle and not a leak at all. The connections that caused the trouble were arranged as shown in Fig. 1. The granulated copper tube lining the steel packing nut had deteriorated so the cuprous chloride solution could come in contact with the steel and form gas.

To remedy the fault, the glass tube was replaced by

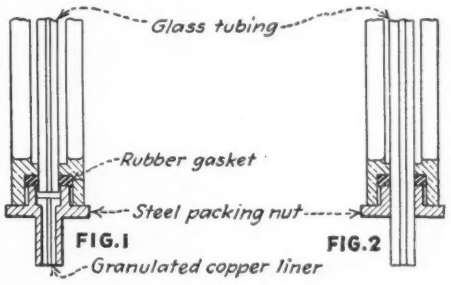


FIG.1 FIG.2

a longer tube extending through the packing nut to the bottle, as in Fig. 2. The tube part of the packing nut was cut off and a hole drilled in the body large enough for the tubing. The rebuilt connections were entirely satisfactory and have the advantage of eliminating two possible sources of leakage.

GERARD PESMAN

Bozeman, Mont.

Dust on Slip Rings Causes Single-Phase Operation

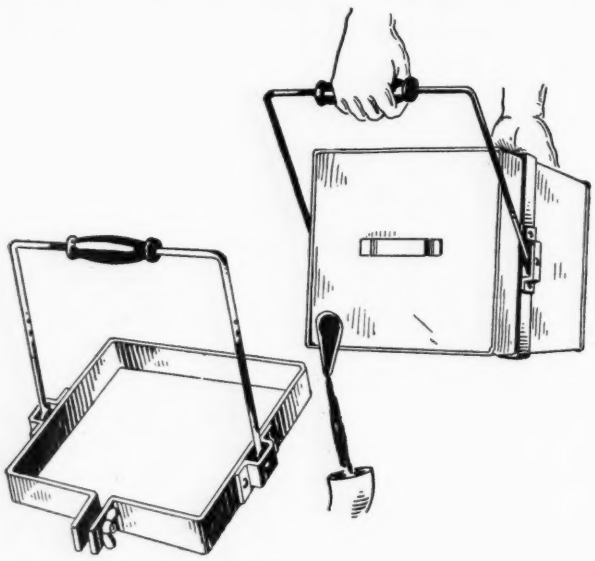
AN INSTANCE of single-phase operation of a three-phase motor may be of interest. The motor was of the wound-rotor slip-ring type wtih the rings uncovered, driving an air compressor in a very dirty place. The dirt would

collect on the rings and brushes and cause them to break contact. The effect on the service was severe. The feeder ammeters indicated unbalancing with violent pulsations that caused objectionable flickering of lights. Placing a dust-proof housing over the slip rings solved the difficulty.

Brooklyn, N. Y. C. O. VON DANNENBERG.

A Handy Oil-Container Carrier

A SQUARE five-gallon oil can is awkward to pour from with the small tin handle that is part of it. Where one has many of these to handle the task can be aided by



making a special carrier as in the diagram. The band is formed to fit a standard square can and has a clamping screw and nut to tighten the carrier to the can.

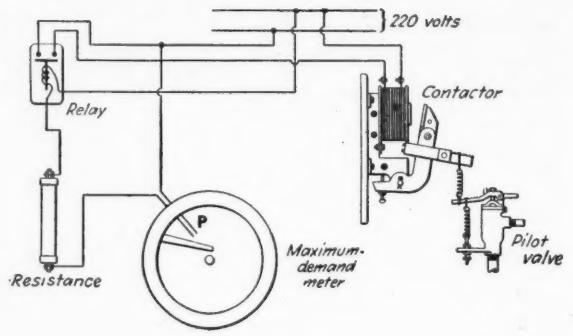
Penacook, N. H. CHAS. H. WILLEY

Unloads Air Compressor To Keep Down Peak Loads

IN A MINE where an electrically driven compressor and hoist are operated, the devices shown in the diagram were installed to keep the maximum power demand down to a given value. On the maximum-demand meter, two contact points *P* were adjusted to close at a certain position of the pen arm. Closing contacts *P* caused the contactor *C* installed above the compressor pilot valve to be energized. The contactor arm is connected by a small spiral spring to the pilot valve level; thus when the contactor closes the pilot valve is lifted to unload the compressor.

The contactor also actuates an electric switch that operates a red light in front of the hoisting engineer. The pen arm on the maximum-demand meter keeps rising during each 15-min. period, the rate at which it rises depending upon the load.

At the end of each period the arm drops, opening the small contact points on the meter. At the same time the contactor on the compressor drops, releasing the pilot-valve lever. The idling compressor then goes into service again. The red light goes out and hoisting can begin.



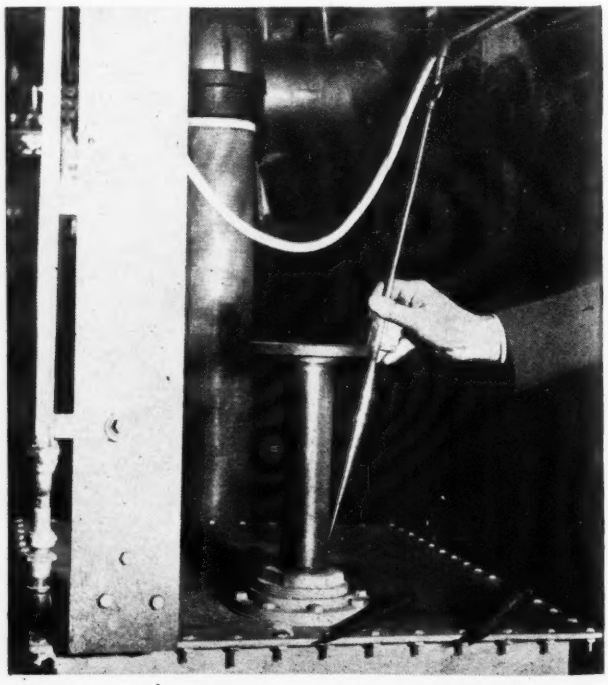
It has been found by trial that 9 skips can be hoisted in a period without exceeding the peak limit.

This arrangement has been in successful operation for over two years. O. W. LEKSTROM

Ironton, Minn.

Inverted Venturi Meter Controls Air Supply

IN TESTING gasoline engines, it is essential that some sort of metering device be provided for air supply to the carburetor, and that provision be made to insure reasonable accuracy over a wide range. Usually, venturi meters are used, but it is difficult to change venturi throats for varying air flows. This difficulty has been overcome at Columbia University by the device illustrated, which is actually an "inverted venturi." Air flows through the straight inlet, past a cigar-shaped central element. This element, carrying the lead tube to the manometer, is suspended in the center of the inlet, and has small holes drilled through at the throat (its *largest* diameter) to its hollow center. Several sizes of elements are available, to provide for any orifice size desired, and the operation of changing them is simple. The device acts as the inlet to the air box, in which is mounted a small blower fan, adjustable in speed to provide the desired amount of air to the carburetor.



CURRENT COMMENT

Welded Pipe, Pro and Con

IN THE June number, page 317, Wm. Anderson asked for comment on relative costs of cutting, threading and reaming 4-in. pipe Like him, I question that these three operations can be done in one minute, and if so, this rate cannot be maintained. In establishing cost for piece work, it will not do to take any single performance, but instead, the amount that can be averaged in an hour. Thus it would be impossible to cut and thread sixty pieces per hour with one machine.

I think that 30c. per cut, etc., is a little high; as a rule, 10c. being the usual charge on cuts of 4 in. and smaller. This is not excessive when one has to stop and get the required length of pipe, examine it for correctness, bring it to the machine, chuck it, cut, thread and ream, then release chuck and deliver pipe to truck or bearer.

Presence of scrap does not necessarily imply poor workmanship or design; pipe comes from the mill in random lengths, and specifications usually call for exact lengths between fittings. It is cheaper to waste a foot or two than to have two men take a steel tape and spend half an hour sorting over a carload of pipe to find the exact length or one that will cut to a minimum waste Moreover, short lengths can be, and usually are, cut into long and short nipples of standard length and used sooner or later. This applies equally whether threading or welding is used.

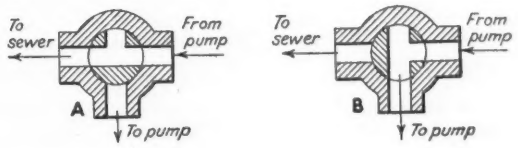
As to the respective merits of welding and threading, it depends on the welder. Like the poet's little girl, when welding is good, it is very, very good, etc., but in general, the character of the work has improved greatly in the last ten years, and the petroleum industry is largely responsible for it. There is no doubt that it has come to stay, but there will also be pipe threading and fitting in some cases.

St. Louis, Mo. L. R. BAKER.

Float Control of Steam Pump

THE pump control described by E. R. Hallam in the June number page 313, was quite ingenious and no doubt worked satisfactorily. However, anyone experiencing the same trouble I would advise to use the old float valve, if it is any good With a large, weighted, flat, well-guided float similar to the one installed by Mr. Hallam on the discharge valve, the sliding stem on the steam throttle valve will not give trouble from binding. It is not necessary to remove the packing from around the sliding stem as Mr. Hallam did, but select a packing that will not swell from the action of steam. Additional pressure may be obtained also by lengthening the lever on the float side.

If any extra precaution is desired against the sump running dry and losing the priming on the pump, a three-way, three-port cock of the lubricated type may be installed on the discharge line to the sewer. This cock would be operated by a float to be in position *A* when the water level in the sump is high, and in position *B* when the minimum safe low level is reached. This additional precaution is unnecessary, in my opinion, but



it would cost less than a new diaphragm and globe throttle float valves.

Pittsburgh, Pa. BERNARD KRAMER.

Increases Crown on Pulleys to Stop Belt Wabble

IN THE June number, answers are given to the question regarding belts that wabble across the faces of their pulleys. The best remedy I have found is to increase the crown of the pulleys. This has been done by applying a few layers of friction tape around the face of the pulley, wound on against the direction of rotation.

Kalamazoo, Mich. R. M. EMMONS,
Chief Engineer,
Division of Lighting.

Obstructed Explosion Relief Doors Wreck Boiler Setting

I WISH to emphasize the remarks of Harry M. Spring who, in the July number discusses explosion relief of boiler furnaces. Explosion-relief doors are like the Westerner's guns—" When you need 'em, you need 'em bad!"

A few years ago I visited a plant that had suffered a wrecked boiler setting from an explosion in the furnace. The fuel was natural gas. The setting was provided with a number of explosion-relief doors that were hinged at the top and rested on a surface inclined slightly from the vertical to insure closure by gravity. Rather astonished at the extent of the damage under what seemed like ample pressure-relieving capacity, I raised one of the explosion doors and found the opening filled with loose bricks. Passing on to the others I found them similarly treated. I was told that the boiler contractor followed the practice of filling the openings with loose bricks to reduce the heat loss through the bare iron doors. He considered the setting sufficiently protected against explosions because the pressure would blow out the bricks and thus vent the gases. Any furnace explosion that would blow a pile of bricks out through the opening, raising a cast-iron door in transit, will certainly severely damage the setting as ordinarily constructed.

Recently my attention was called to the practice of another furnace builder who filled up relief openings with bricks for the purpose of reducing the heat loss through the door. It would seem that a cast-iron door could be fairly well insulated against heat loss without completely nullifying its proper function. There could be applied to its inner surface two, or three, thicknesses of asbestos composition boards with spaces between formed by washers of the same material, and held to

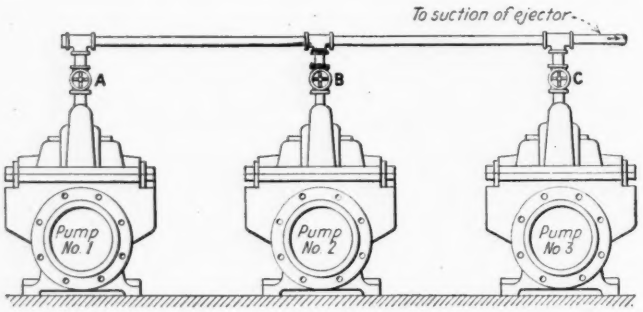
the door by bolts. The heat loss through a few cast-iron explosion doors seems insignificant when compared with the loss of the setting.

Bricking up an explosion-relief opening in a boiler setting is reminiscent of early river-steamboat days when a "nigger" was set on the lever of the safety-valve to increase the operating pressure during races.

Los Angeles, Calif. C. O. SANDSTROM.

Uses Ejectors to Prime Pumps

I HAVE read with interest the articles on priming of pumps in several recent numbers of *Power*. The figure shows an arrangement that I have used to prime a group of pumps with an ejector. Valves *A, B* and *C* allow priming any one of the pumps without interfering with the operation of the others. To prime, say pump No. 2, open



valve *B* and put the ejector into operation. When the pump is primed water will discharge from the ejector after which the pump is started.

Another method is to connect the priming line to a condenser operating at sufficiently high vacuum to prime the pumps. When this method is used care must be taken to insure that the valves are closed in the priming line after the pumps are primed. When using this method of priming, I have installed two valves in the priming line to make sure that there would be no leak into the condenser.

Detroit, Mich. LEONARD LONG.

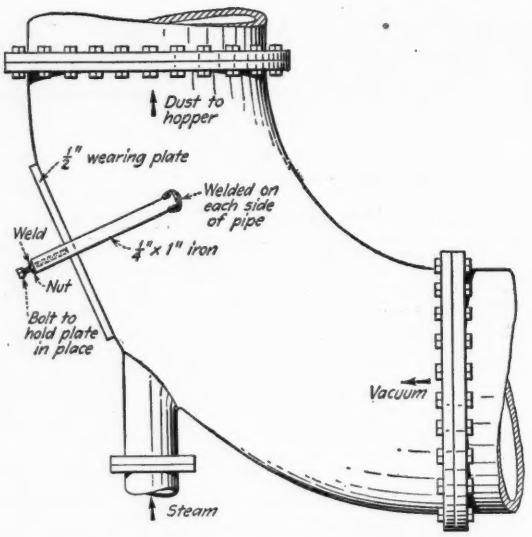
Cold Glue Used as Belt Cement

THE article, "Cold Glue Used as Belt Cement," by Nels Hilsen, in the July *Power*, corresponds to my experience. Cold liquid cement on glue for belts will be improved, however, if a small quantity of potassium chloride is added. This prevents the cement from becoming so hard that it cracks.

Toronto, Ont. JAMES E. NOBLE.

Steam-Jet Vacuum Cleaner for Power Plants

I RECENTLY saw a steam-jet vacuum system similar to that described by A. R. Markland in the July number of *Power*. Trouble was caused by the dust and sharp coal particles gradually eroding and cutting away the side of the steam-jet casting where they impinged due to their high velocity. It was decided to



install a hardened-steel wearing plate where the erosion occurred.

A piece of ¼x1-in. strap iron was bent in a U shape and welded on the two sides of the elbow, as in the figure. The section of the elbow subjected to erosion was cut away with an acetylene torch. The cut edges were then ground smooth and straight. A piece of hardened manganese steel was obtained ½-in. thick and of dimensions to cover this opening. A $\frac{9}{16}$-in. hole was drilled through the U-shaped strap and a ½-in. nut was welded over this hole, which came over the center of the wearing plate. When the wearing plate was in position, it was held there by a bolt threaded into the nut as in the diagram. This had been in service for over a year when the writer examined it, with little sign of erosion. Before this, the casting had worn through in much less time.

Milford, N. J. HARRY M. SPRING

Reduces Pulverized-Coal Burner Size to Improve Operation

IN AN industrial power plant, the boilers were fired by a unit pulverized-coal system, using plain venturi-type burners. The boilers operated with an efficiency of about 70 per cent and 10 per cent CO_2. These values could be considerably improved by reducing the excess air, but when this was done the burners were destroyed in a short time. In attempting to secure better combustion, three burners were burned up in less than two months in spite of especial care being taken to prevent this trouble

The burner specifications were consulted and it was discovered that they were designed for 600 per cent boiler rating. The average boiler rating in this case was 250 per cent, and at times the load dropped to 150 per cent for several hours at a time. It was known that each time the burners overheated the boilers were on light load. The burners, being of so much greater cross-section area than necessary, had caused too low a coal-air velocity at low loads. With the correct amount of secondary air for the steam flow, the fire would back up into the burners. This would quickly cause coking wherever a slightly roughened spot would give it a start. Installing burners of correct capacity allowed the CO_2 to be increased to 13.5 per cent average with a boiler efficiency of 75 to 79 per cent.

Cleveland, O. M. E. WAGNER.

OPERATING EXPERIENCE WITH PROPELLER-TYPE RUNNERS

Here are summarized operating experiences with 63 propeller-type turbines, representing 752,250 hp. installed in Canadian hydro plants, together with the difficulties met with in their operation. Unit sizes range from 400 to 37,500 hp., and for heads from 8 to 66 ft.

AS PART of the work done by its Hydraulic-Power Committee, a report was presented on operating experience with propeller-type runners at the Forty-Third Annual Convention of the Canadian Electrical Association held at Luzerne-in-Quebec, June 14-16. Inquiries were sent to practically every Canadian plant using propeller-type runners. Twenty-seven replies were received, covering 63 units with a total capacity of 752,370 hp. The capacity of these units ranged from 400 hp. to 37,500 hp., for heads from 8 to 66 ft.; speeds from 85.7 to 400 r.p.m., and specific speeds from 105 to 211. The runners varied in diameter from 58 to 200 in.

While several of these plants have had considerable maintenance expense due to pitting of runners and stationary rings, as a whole, propeller-type waterwheels have been satisfactory. Differences in the operating characteristics, as compared with lower-speed francis-type units, caused some inconvenience when the plants were first started, but in the majority of cases this disappeared after the operators became accustomed to the equipment.

Twenty-seven plants reported. In 22, containing 50 units, the runners are of the fixed-blade type; in three plants, containing nine units, the runners have manually adjusted blades; and in two plants containing four units the runner blades are adjusted automatically. In 14 plants, containing 35 units, the runners have six blades; in 15 plants, with 26 units, the runners have four blades, and in one plant of two units, the runners have three blades. All units are of the vertical shaft, single-runner type.

Three plants, containing four units, have operated nine years and over; four plants with eight units, have operated eight years and over; seven plants, comprising 16 units, have operated six years and over; and ten plants of 24 units, have operated five years and over.

Five plants, containing 12 units, reported severe pitting on the runners; eight plants comprising 15 units, reported slight erosion or bright spots on the runners; 15 plants with 27 units, reported no pitting or erosion; and two plants have not been inspected. Of the five plants reporting severe pitting, four have operated six years or longer; the other plants being in operation only one year.

On four of the plants, a considerable cost for repairs has been entailed due to pitting. One plant reported $250 per unit per year, a second plant $2,000, and a third $1,500. In the report on the fourth plant the cost of repairing pitting on the runners was not given.

The other plants spent no money to repair pitting, but in four it is estimated that some repairs, due to this cause, will have to be made within five years; seven within ten years. Twelve operators are of the opinion that their plants will run indefinitely without appreciable damage due to pitting.

Operators of 10 plants were of the opinion that propeller-type units were harder to synchronize than units of the francis type, and 16 reported that they were not. One had no experience with francis wheels, so could not give any comparison. The general opinion of those finding propeller-type units more difficult to synchronize is that the difficulty is of no consequence, and is overcome by experience in operating the unit.

Operators of six plants reported that venting the draft tube aids synchronizing, and six reported that it did not. Thirteen have not vented the draft tubes, while one reports having had no experience with unvented draft tubes. One plant was automatically synchronized.

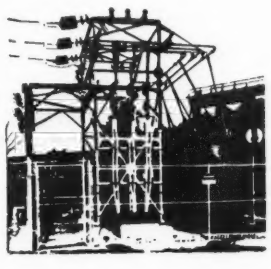
Operators of eight plants reported that high tailwater makes synchronizing more difficult, and ten did not find any trouble from that cause. One plant operator reported that high tailwater actually aided synchronizing. Six have had no experience with high tailwater.

Operators at 21 plants reported no trouble from vibration. Six reported slight variation, but not serious.

In general operation of propeller-type units is found to be satisfactory, although it would appear that in some of the older plants considerable trouble was experienced before overcoming their difficulties.

Dealing with specific information from the various plants, the replies under erosion and pitting troubles are of considerable interest. The operators of one large plant expressed their experience as follows:

"The plant operated initially under a head of about 33 per cent of normal. After a few months, pitting was found on the runners, the trailing tips of the blades being quite badly pitted and spongy, and slight pitting was found on the top part of the runners. Very severe pitting was found at the base ring in line with the leading tips of the blades. The base ring was of cast iron, and after a comparatively short time pitted to a depth of over 1 in. The pitting started in spots at equal distances around the ring, corresponding to the number of guide vanes, and ultimately extended around the complete circumference.



"As the head was raised, the pitting on the trailing tips of the blades was accentuated. It was found that as the head increased, pitting on the base ring completely ceased at the level of the leading tip of the blade, but continued below this level until finally the ring was eroded through in places. Welding was tried to cure this, but a satisfactory job could not be made. Finally, the faulty metal was cut out and a complete new liner of mild-steel plate installed, patch bolted to the back ribs on the rings, welded along the joints and ground smooth. Within less than a year this liner became loose, patch bolts came out, and one plate cracked. Conditions became so serious that a new base ring, built up of steel plate, was installed. The other unit was similarly repaired, but because the damage was not so serious and because a better hold for the patch bolts, is still in service, although from appearances it is only a matter of time before the ring will have to be replaced.

"The next machine was purchased with steel-plate liners fitted into the base ring. Pitting on these rings has been practically negligible, but there are indications of the rings becoming loose and breathing, and it is questionable how long it will be safe to operate. It was found impossible to tighten up the rings, as the patch bolts holding the plates to the casting have become loose, evidently due to vibration, and in some cases threads were stripped, both on the bolts and in the holes.

"The other machines were installed later. On the manufacturer's recommendations cast-steel base rings were used. Pitting on these rings, on the lower edge, level with the trailing tip of the runner, was as bad if not worse than on the cast-iron ring, and extensive repairs will shortly have to be made on these rings. As they are cast steel, welding can be used.

"In general, considerable trouble has been experienced with draft-tube liners coming loose. Apparently the method of anchoring these liners to the concrete, and the plate to the stiffening angle, is not satisfactory.

"Pitting of the trailing tips of the blades is severe, and after spending considerable sums on building up such affected areas by welding, both with special alloys and ordinary steel and then grinding smooth it was found cheaper to cut out the faulty part, machine a piece of plate steel to match and weld it in. It is significant that these plate-steel tips have shown no signs

of pitting. This indicates that a good deal of the trouble on the runner tips is probably due as much to unsuitable material as to faults in the design of the runner. It is suggested that this may be due to the difficulty in securing good metal at the thin tips when casting. A cure for the trouble would be to build the trailing tips of this type blades with plate steel, welded to the main body of the cast-steel blade.

"While there is no question that pitting troubles may be primarily due to incorrect design, the above experience would indicate that material has almost as great an effect. This is borne out by experience on the base ring, as under identical conditions of running bad pitting has occurred with both cast iron and steel, whereas with plate-steel no trouble has occurred."

Another reply states that bad pitting of the base ring occurs at points approximately in line with full-open position of the guide vanes, and is confined chiefly to the lower 3 or 4 in. of the ring. This pitting commences in small areas corresponding in number to the number of guide vanes. These gradually increase until in the course of a year's time they are about 12x3 in., and possibly ½ in. deep, and eventually join all around the draft tube. Welding with stainless steel appears to retard this pitting, and after a few years' experience, repairs are required only once in two years instead of each year as formerly.

The same reply states that pitting on the runner blades take place at the leading tip, along the leading edge, but more severely on the trailing tip. Stainless-steel welding has been found to be very useful on these parts, and whereas formerly the repair work directly chargeable to pitting was in the order of $1,500 per year per unit, this has now been reduced to approximately $500 per year. On new units some plant operators have the surfaces of runners that might be subject to pitting welded with stainless steel, and indications are that probably five years' service will be obtained before repairs are necessary.

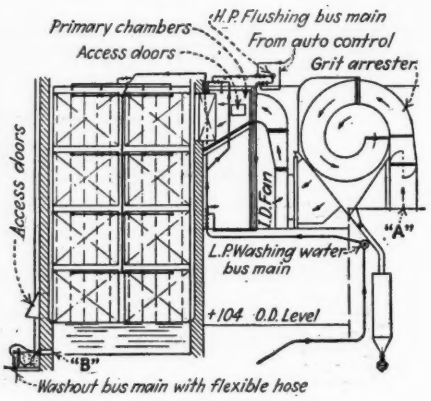
Operators of another plant report considerable pitting on the cast-iron base ring and runner tips after a short service period, but after installing a new steel-plate base ring no pitting has been observed to date. Two other plants report slight pitting on the runner after two years, but none on the throat ring.

Operators of another plant have had considerable pitting on runner blades and on the base rings in line with the leading tips of the blades, directly below the gates. This pitting was quite pronounced the first two years, and then increased only slightly, although there are signs that it is progressing.

Operators of two other plants, which have been in service for a few months only, report indications of pitting on the trailing edges of the runner blades. In this case the runner is submerged several feet below normal tailwater level.

One company reports that the surfaces of its runner blades and the base ring are welded with chrome-nickel steel before installation, and after three years' service have given no signs of erosion.

The information received in the inquiries does not throw any new light on the causes of pitting, nor does it show any definite relation between pitting, specific speeds and cavitation factor. Such a relation involves a question of design not covered in the inquiries. The only definite inference is that certain materials are more subject to pitting than others, which is borne out by laboratory tests.



Section A-A

BATTERSEA REMOVES FLUE DUST

By G. W. HEWSON, S. L. PEARCE, A. POLLITT and R. L. REES*

THE rate of flow of flue gas from Battersea station when completed will be of the order of 1,500,000 cu.ft. per min. at N. T. P. (normal temperature and pressure). The initial concentration of sulphur dioxide in the gas will lie between 0.02 and 0.05 per cent by volume, and it is possible to reduce this 90-95 per cent before discharging the gas to atmosphere. Battersea uses wet treatment of the gases, the process being: Gas from coal containing about 1 per cent sulphur is washed with water during its passage through scrubbers in which both gas and water are brought into contact with iron oxide. The gas is then scrubbed, preferably in contra flow, with water in another chamber, the scrubbers being of an inert material such as wood. After passing upward through the water sprays, the gas enters a final scrubber wetted with an alkaline solution, i.e., 25 per cent chalk slurry. Gas is then discharged, after passing through a dry scrubber to remove entrained moisture. The alkaline solution flows downward to mingle with water from the sprays. If gases were at N. T. P. and washer empty, they would require 30-35 sec. to pass through the washer. About 20 tons of water and 10-12 lb. of lime or chalk are used per ton of coal burned at a cost for pumping and alkali of about 3d. per ton of coal.

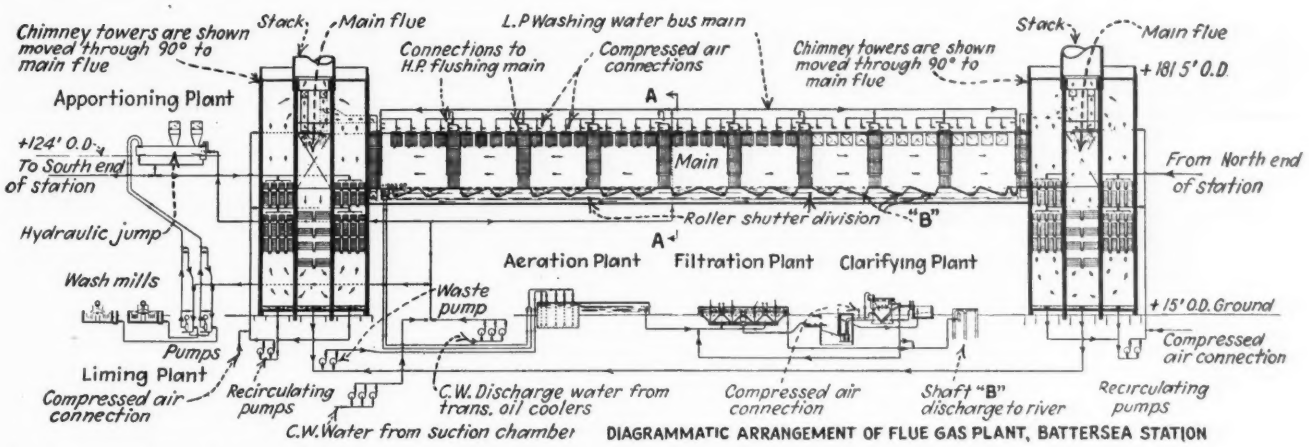
Entrained air bubbles are produced in the wash water by brisk aeration, and the effluent from the whole plant is also aerated to oxidize sulphites. Total replacing power of the effluent may thus be made equivalent to as little as 3 grains of sulphur per gal., in the form of sulphite. A very small amount of manganese in solution will promote oxidation still further. After filtration, the effluent is diluted with about 25 times its bulk of return condensing water, which is sufficiently alkaline to neutralize acidity of the effluent.

The gas-washing plant is designed to treat gases from a battery of nine boilers constituting the first half of the station. Each of the first six of these boilers has these ratings: normal economic rating, 250,000 lb. per. hr.; maximum continuous rating, 312,000; peak rating, 330,000. The main flue runs above and parallel to the row of boiler units. Coal consumption of each boiler unit at 330,000-lb. rating is 19 tons per hr., and the plant is designed to have seven units running constantly at this rating—or 133 tons of coal per hr. On the basis of 13 per cent CO_2, the total weight of gas is thus 3,600,000 lb. per hr.

Gases, after passing through boilers, superheaters, economizers and air heaters, are drawn by four induced-draft fans per boiler into grit arresters and discharged to the primary chambers. They then enter the main flue and descend the center chamber of either of the chimney towers. At the base, gases bifurcate, ascend outer chambers and pass through the eliminator plates to the base of the chimney proper, where they are diluted by warm air entrained from a chamber beneath the main flue. During the progress, gases are brought into contact with five distinct banks of scrubbers. First, at the exit from primary chambers into main flue, the gases, previously wetted, are brought into contact with a bank of steel channels. Next, they strike similar channels in banks in the main flue; third, steel channels set horizontally in the descending bank of each chimney tower; fourth, a vertical set at the bottom of the chimney towers. These also prevent too great a proportion of the liquor from early stages being carried into the alkaline wash, which is sprayed on the fifth series of scrubbers, made of wood and in the wing chambers or uptakes of the chimney towers. No sprays are used on the last bank of metal scrubbers, since gases are carrying much free wash water in suspension.

Primary chambers—One on discharge of each induced-draft fan, a group of four chambers per boiler really constituting a taper connection between fan discharge and main flue, with their floors sloping downward 30 deg. to the flue, other walls being square. Their cross-sectional areas are 43 sq. ft. at inlet and 64 at outlet 9½ ft. away, with a 3-ft. bank of scrubbers extending the full area of the outlet end.

*An abstract of a paper, "The Application to the Battersea Power Station of Researches into the Elimination of Noxious Constituents from Flue Gases, and the Treatment of Resulting Effluents," before the Chemical Engineering Group Session of the annual meeting of the Society of Chemical Industry, at Newcastle-on-Tyne, England, July 11. Only a small part of the paper is here given.



DIAGRAMMATIC ARRANGEMENT OF FLUE GAS PLANT, BATTERSEA STATION

Scrubbers can be replaced easily by closing dampers on any outlet. River water sprays gases here, merely to wet them and precipitate any residual solids (which passed through the grit arresters) into open troughs below main flue. With the fans in action, the water enters the flue as a mist in the gases.

Main Flue—Constant rectangular section 38 ft. high by 23 wide (874 sq.ft. cross-section) running full length of station, 475 ft. Troughs across its bottom are awash with water to provide maximum wetting of flue gases and also to carry away heavier grits sludged through connections marked *B*. Sludge is drained in receiving trough on roof of adjacent turbine house, then removed in relatively dry state.

Ten banks of scrubbers similar to those in primary chambers, each 7 ft. 7 in. deep and extending over entire cross-section of flue, are arranged one between discharges of each group of primary chambers for each boiler and one at each end of flue. By means of roller shutters, one between banks 3 and 4 and the other between 6 and 7, either chimney may be isolated and the gases from boilers on the live side made to pass to the other chimney.

Chimney Towers—Each consists of three sections, one downtake, two uptake, and carries the eliminator and chimney itself. The downtake, 36½ ft. by 24½ ft., (Cross-section, 894 sq. ft.), is 122½ ft. high. Four banks of scrubbers, each 4 ft. 8 in. deep and across full section, are in each downtake, and a vertical bank is in each passageway at the bottom. Uptakes are 36x20 ft., giving total cross-sectional area per tower of 1,440 sq. ft., and are 60 ft. high. Two banks of scrubbers, 1 lower 25 ft. 9 in. deep and upper 14 ft., of pine wood, are set in. The alkaline wash is sprayed on the upper scrubber, then caught at its bottom and sprayed again through two groups of sprays lower down in the uptakes and one in the roof of downtake.

The eliminator banks are in parallel rows above the roof plates of the downtake and with two walls of the towers form a chamber at the base of the chimney proper. These eliminators are of wood and each contains two banks of eliminator elements, 1 ft. 4 in. deep, set vertically to remove free moisture from the gases. Warm air from the boiler house is also introduced here to dilute gases and assist in drying and dispersal.

Chimneys, above the eliminators, are 28 ft. 2 in. in diameter (622 sq. ft.) at base and 22 ft. in diameter (380.13 sq ft.) at top. They are 171 ft. high, with their tops 352.5 O. D., or 337.5 ft. above the ground, and are of reinforced concrete.

Aeration of wash water has been found a necessity. Between the controlling valves and the banks of sprays, air taken from the compressed air system is admitted to the water. The supply of aerated wash water to the sprays is important in the gas-washing system.

Spray water pumps supply water in parallel to the primary chambers and main flue, and there is also a connection to an apportioning plant and a water supply to the wash mills. Water from the primary chambers and the main flue is collected in a common main and taken to the effluent treatment plant. Effluent from the alkaline wash, after its double passage, is also sent to the treatment plant.

Spray water for the main flue and primary scrubbers is supplied alternatively by two groups of three pumps operating in parallel. The first group draws its supply direct from the suction chambers of the main circulating water, the second group from the circulating water mains at the outlets from the main transformer oil coolers, both discharging into a common main to the main flue and primary chambers. A connection from this main to the hydraulic jump of an apportioning plant provides water to be treated with reagent, then fed by gravity as the alkaline wash in the uptake towers.

Treated water from the upper bank of sprays in the uptakes is collected in sumps at the base of the uptakes, then is drawn by recirculating pumps which return the liquor to the lower banks of sprays in the uptakes and the banks of sprays in the roofs of the downtakes. Two pumps are provided per tower, discharging to a common main, and independent of the pumps in the other tower. Each pump is capable of supplying full requirements of a tower.

Liming Plant—Used for production of milk of lime in the proportion of 30 parts of lump lime to 100 parts of water, this plant comprises two 20-ft. octagonal wash mills of concrete. Lime is mixed in the mills with the proper amounts of water by vertically hung gear-actuated stirrers. Resultant lime wash is discharged through screens around the periphery of the mills into two small collecting chambers, whence it flows along pipe lines to two 2 throw pumps which discharge it to the hydraulic jump of the apportioning plant. This plant consists of two reagent hoppers, float tanks, water trough, combined hydraulic jump, and buffer tanks. River water used for spraying is introduced into the end of the main tank and flows through the hydraulic jump, where it is mixed with reagent.

Aeration Plant—This converts sulphites in the effluent to sulphates. It comprises a 30x8x16½-ft. tank which receives the wash water at the base of the chimney tower. Five ejectors for entraining air into the water during its passage to the aeration tank are provided, three for water from the primary chambers and main flue and two for discharge from the chimney tower downtake.

Filtration Plant—This is of reinforced concrete and includes 24 chambers arranged in six rows of four. Filtering media, water-worn stones and sand, are carried by perforated cast-iron floor plates. Horizontal rectangular concrete pipes with hand-operated penstocks and float valves control admission of effluent. Entering effluent goes into the vertical trunk at the center of the chamber. Heavier solids gravitate to bottom (below the perforated plates), while the liquid with lighter solids rises through the filtering medium, depositing the lighter solids on the under side.

Sludge flows through a culvert to the clarifying plant receiving pit. From the pit it gravitates to one of two Shone ejectors which lift it to the deaerating inlet tank whence it flows by a bottom pipe connection to the under side of a sill in the clarifying tank. The sludge enters tangentially and, as the quantity is small, the velocity is low and solids settle to the bottom. Clear water overflows the sill into an annular trough from whence it can be sent either to the inlet or outlet of the sand filter, depending upon its clarity. The sludge is removed from the conical bottom by the difference in hydraulic head when the penstocks on the entrance to the sludge beds are opened. Should the sludge settle hard, a compressed air connection at the entrance of the discharge pipe aids its removal. Sludge is lifted by grabs to carts periodically.

Capital costs of the flue-gas washing plant were:

	Pounds Sterling
Towers	193,070
Filling	8,520
Primary chambers	4,020
Main flue	33,920
Filtering plant	10,590
Aeration plant	1,540
Lining plant	2,520
Pumping plant	2,150
Pipework	7,380
Valves	1,730
Sprays	630
Pressure distributor	580
Jib cranes on towers	900
Cables and switchgear	5,750
Incidental work	700
Total	£274,000
Credit for building steel saved in putting chimneys on towers	27,600
Net extra cost	£246,400

READERS' PROBLEMS

Zeolite Softener

ZEOLITE SOFTENER—*The accompanying table gives a recent analysis of our water supply. I have noted, in many copies of* POWER, *useful suggestions on water treatment and thought that you could give me some ideas as to what would be an economical and positive treatment for this water.*

We had a zeolite softener and used it for a few years, but the water eroded the softening mineral so rapidly that the manufacturer of the mineral advised us to discontinue the use of a water softener, due to the high salt content and the lack of silica in the water. Have you any suggestions? A.E.F.

	P. P. M.	Gr. Pr. Gal.
Oxygen Dissolved	4.2	
Free Carbon Dioxide	7	0.4
Carbonate	0	0
Bicarbonate	52	3.0
Sulphate	91	5.3
Chloride	414	24.2
Calcium	74	4.3
Magnesium	22	1.3
Sodium	205	12.0
Iron	Trace	Trace

[The following reply was prepared for POWER by William J. Ryan of the Water Service Laboratories, Inc., New York City—Editor.]

Since the letter does not state for what purpose the water is to be used we shall assume its use for general supply including boiler feed, as in a hotel, or for boiler feed only. The analysis shows that a zeolite softener is the proper treatment in either case.

Lime and soda-ash treatment will not give as low a hardness as zeolite, and with this water it would not effect any appreciable reductions in dissolved solids because the hardness is practically all non-carbonate hardness. Also the treatment would require a large amount of soda ash as compared to the amount of lime, which would probably make it more expensive than the corresponding amount of salt required to regenerate a zeolite softener.

Furthermore, in a small plant, a lime soda-ash softener would require too much attention, particularly in view of the close regulation of the treatment required if the water is to be used for drinking purposes.

Internal treatment also offers no advantage over a zeolite softener in this case. In fact, it would have some very strong disadvantages, because if soda ash were used to react with the non-carbonate hardness it would precipitate a large amount of calcium carbonate in the boilers. Moreover, as stated above, the amount of soda ash required would probably be more costly than the amount of salt required in the zeolite softener.

A. E. F. doesn't state if he had any trouble with the water when the zeolite softener was in use, as for instance scale in the boilers. We therefore assume that his trouble was simply the expense incurred by the loss of mineral. It is true that there are some zeolites that will not stand up very well with a water like this, but there are other zeolites, both synthetic and greensand, which will handle such a water without any appreciable loss by attrition.

We would suggest that A. E. F. get in touch with some of the people who supply these minerals and explain his requirements, so that they can furnish the kind of mineral that he needs.

Changing Induction Motor Speed

INDUCTION-MOTOR SPEED REDUCED—*I have a 3-hp. 3,600-r.p.m., squirrel-cage, induction motor that is to be changed to operate at 1,800 r.p.m. on the original voltage and frequency. What changes are necessary in the windings and what horsepower will the motor be good for?* M. A. D.

The winding will have to be changed from a two-pole to a four-pole grouping, which will require rewinding the coils. Since the motor is to operate on its original voltage at one-half speed, the number of turns per path in the winding will have to be doubled. This can be done by rewinding the coils with double the number of turns of wire one-half the original cross-section.

Because of the reduced span of the coils in the four-pole winding, they can be made shorter than the original ones. If this is not done their ends may extend out far enough to interfere with putting the end bells in place.

Any change made in the pitch of the coils will affect the voltage they are good for. Therefore in the new winding the coils should span, as nearly as possible, the same number of electrical degrees. For example, if the stator core has 24 slots, then in the two-pole winding full pitch of a coil equals $24 \div 2 = 12$ slots. If the coils are in slots 1 and 11, they span 10 slots. Full pitch of 12 slots equals 180 electrical degrees, and one slot equals $180 \div 12 = 15$ deg., then the coils have a pitch of $10 \times 15 = 150$ deg.

In the four-pole winding, full pitch is equivalent to $24 \div 4 = 6$ slots, and one slot is $180 \div 6 = 30$ electrical degrees. For the four-pole coils to have the same pitch as the two-pole coils, they will have to span $150 \div 30 = 5$ slots. Assume one side of a coil to be in slot No. 1; then its other side should be in slot No. 6. The grouping of the windings will be the same as in the original. If the two-pole winding was grouped two-pole series-star then the new winding should be connected four-pole series-star.

Reducing the speed of the motor by one-half will reduce its rating from 3 to 1.5 hp. If the 3,600-r.p.m. motor has been closely rated, it may be found that at 1,800 r.p.m. it will not be good for 1.5 hp., because of the decreased ventilation at the slower speed.

Low Motor Voltage

LOW VOLTAGE ON 3-PHASE MOTORS—*Our motors operate on 3-phase, 208-volt power and range in size from 1 to 25 hp. When the voltage decreases to 200 volts, does the power taken by the motors increase to drive a given load?* H.U.W.

With the power output and frequency remaining constant, the effects of operating an induction motor on low voltage is to decrease the field strength and therefore the iron losses. The magnetizing current is decreased. Since the reactance of the winding remains constant, the short-circuit current, starting torque and pull-out torque are decreased.

Because of the decrease in the magnetizing current, the power factor is higher. On account of the increased load current resulting from the lower voltage, the copper losses are increased. The efficiency may be lower because of the increase in copper losses, but these losses are likely to be more than offset by the decrease in iron losses, in which case the efficiency might increase slightly.

Under the foregoing condition the worst features of operation, providing that the torque characteristics are satisfactory, are that the added losses are not uniformly distributed, but are localized in the copper, the iron losses decreasing. The copper losses increase as the square of the current, and for this reason are likely to cause dangerous heating of the windings if the voltage decreases more than 10 per cent.

Induction motors are generally designed to operate satisfactorily on a 10 per cent increase or decrease in voltage when the frequency is normal. In the case under discussion, the voltage decrease is less than 4 per cent, consequently the motors should operate satisfactorily, and, for a given load, the power consumption should be about the same as when operating at normal voltage.

Firing in Comfort

BOILER-ROOM COMFORT—*We operate a hand-fired boiler room and find that during the summer the firemen suffer a good deal from heat exhaustion. What can be done to help these men?*—C.R.B.

Several things might be done to make your boiler room more comfortable to work in. Look around and see if the steam and hot water pipes are properly insulated. An improvement in insulation would decrease the heat loss to the boiler room, so saving fuel as well as making the boiler room cooler.

It would also be feasible to install a system of forced ventilation; the air removing the heat from the boiler room and the air movement creating a cooling effect on the men.

Installation of stokers would increase the manual labor required of the firemen and at the same time increase boiler-room efficiency.

In the meantime, however, medical authorities recommend common table salt as a remedy for heat exhaustion. A. F. Lacklider, M.D., says that heat exhaustion is always associated with excessive sweating and that about 98 per cent of the perspiration is water, the 2 per cent of solid being to a great extent common salt. He pointed out that the accompanying heavy drinking of water replaces the water but not the salt, leaving the body in an unbalanced condition. In a steel plant it was found that giving large quantities of salt water caused the disappearance of cramps within thirty minutes or sooner. It was also found that the routine use of salt drinking water prevented the occurrence of

any case of cramps. "According to the Journal of the American Medical Association it is not known that any harmful results will develop from the use of salt in normal persons engaged in hard work and given to excessive sweating . . . Salt may be given in any form, as for instance in ten-grain tablets placed in containers close to drinking fountains, one tablet to be used to a glass of water, or in the form of a dilute solution of ½ of 1 per cent. When chilled, this solution is palatable and assists in cutting down the desire for great quantities of fluid."

Two Questions for Our Readers

Will Increased Pressure, Even if Throttled, Cause Engine Trouble?

QUESTION 1

SOME *time ago we installed a new uniflow engine and increased our steam pressure from 100-lb. to 160-lb. gage. When the new engine went into operation, our old four-valve Corliss engine was shut down, but not dismantled.*

Recently the load has increased so that it has become necessary to operate the Corliss engine again. The steam pressure was reduced to 100-lb. pressure by hand regulation of a valve in the line to the engine. Under these conditions the engine labored and pounded badly, although it had operated satisfactorily when last used.

We then tried operating by reducing the pressure carried on the boilers to 100-lb. pressure. Under this condition the engine operated as well as it had before the new engine was installed.

In starting the Corliss it was our practice to operate the valves by hand. With the throttled steam pressure it was almost impossible to move the valves, but when 100-lb. boiler pressure was carried the valves were easy to operate. The pressure gages were carefully checked and found correct.

I shall appreciate it if some POWER *readers can tell me what makes the engine operate so poorly on steam reduced from 160-lb. to 100-lb. pressure when it operates all right when 100-lb. boiler pressure is carried.* A.A.T.

How About Blowdown?

QUESTION 2

I HAVE *been told that blowing down a boiler through a standard hand-operated blow-down valve is more effective in removing boiler sludge than when a continuous blow-down system is used. I should like to know whether* POWER *readers' experiences indicate this to be so.* R.P.N.

Suitable answers to these questions from readers will be paid for if space is available for their publication.

Precooling to Avoid Condensation Troubles

Answers to July No. 2 Question

JULY QUESTION

THE *agitation air which we use in our ice-making plant is compressed to 28 lb. and then reduced to 15 lb. pressure before going to the agitators. To what temperature should this air be cooled in order to avoid trouble from condensation and freezing in the air lines to the ice tanks?* N.R.O.

Moisture Table Answers Problem

THE following table will answer your question. Assuming the free air to be at 14.7 lb. abs., then compressed to 28+14.7, or 42.7 lb. abs., and later reduced to 15+14.7, or 39.7 lb. abs., the problem is to find the minimum temperature of the air before release. If the agitation air is conducted down through a duct in the side of the can, the air is chilled to within a few degrees of the brine temperature. In chilling the air at 28 lb. in the dehumidifier, it is cooled to the saturation point, and, moisture may be removed. However, upon reducing the pressure, the *volume* of the air is increased, but the total moisture content is not changed. Hence there is less vapor per cubic foot than would exist at the saturated condition. The air at 29.7 lb. abs. may be again cooled to the saturation point without producing frosting or precipitation of moisture, which may freeze. Cooling below the saturation point will precipitate moisture which can freeze and cause stoppage of the agitation line either in the laterals or in the can duct.

Temp. of Air, Deg.	Grains Moisture per Cu.Ft.Sat.Air	Temp. of Air, Deg.	Grains Moisture per Cu. Ft. Sat. Air
10	0.772	35	2.380
12	0.850	36	2.470
14	0.934	37	2.566
16	1.027	38	2.662
18	1.127	39	2.763
20	1.237	40	2.867
22	1.355	41	2.975
24	1.485	42	3.085
26	1.624	43	3.200
28	1.777	44	3.320
30	1.943	45	3.441
32	2.122	46	3.567
33	2.207	48	3.830
34	2.292	50	4.113

The following two examples show how to use the table:

If the air in the dehumidifier is chilled to 32 deg. at 28 lb. gage (42.7 lb. abs.) and then expanded to 15 lb. gage (29.7 lb. abs.), to what temperature may the air be chilled at this lower pressure without producing precipitation or frosting.

At 32 deg. F., 1 cu.ft. of saturated air from the dehumidifier contains 2.122 grains of moisture. If the air is reduced from 28 lb. to 15 lb., the volume is increased to $\frac{42.7}{29.7}$ or 1.437 cu.ft. and the total 1.437 cu.ft. contain 2.122 grains or $\frac{2.122}{1.437} = 1.477$ gr. per cu.ft.

The table shows that the air may be chilled to 24 deg. or slightly less before precipitation occurs.

If the brine is at 14 deg. F. and the air is found to be at 18 deg. F. in the laterals or ducts when at 15 lb. gage pressure, to what temperature should the air have been cooling while in the dehumidifier at 28 lb. gage?

Air at 18 deg. F. may contain 1.127 gr. per cu.ft. without precipitation. One cu.ft. of this air occupied $\frac{29.7}{42.7}$ or 0.6955 cu.ft. when at 28 lb. gage.

The air contained $\frac{1.127}{0.6955} = 1.621$ gr. per cu.ft. when at 28 lb. gage. Hence the air should have been reduced to 26 deg. F. or less.

The above figures must necessarily assume that there is no entrained moisture in the air as it leaves the dehumidifier, i.e., all moisture must be in vapor form rather than existing as small particles of water.

Dallas, Texas R. D. CAMPBELL
Associate Prof. Mech. Engrg., So. Methodist University

Should Precool to 22 Deg.

WHETHER water will freeze in the air lines depends on the amount of water vapor contained in the air. If the vapor content is such that, when the air is cooled, water will condense out, there is danger of this water freezing and clogging the air lines.

When air at 28 lb. gage pressure is cooled, it will probably be saturated. When it is reduced to 15 lb. gage pressure it will expand, and since the volume is much greater, there is not enough vapor to saturate the volume at the same temperature. With brine at 14 deg. F., the air may be saturated at 15 lb. gage and 14 deg. F. without danger of freezing.

Referring to the table by Bulkeley in *Refrigerating Engineering*, January, 1933, the pressure of saturated water vapor at 14 deg. F. is 1.945 millimeters of mercury and the weight of saturated water vapor per cubic foot is 0.935 grains. This pressure is so small compared to atmospheric that it can be neglected without appreciable error.

One pound of air at 15 lb. gage or 29.7 lb. abs. and 14 deg. F. occupies 5.9 cu.ft. The grains of moisture mixed with one pound of this air, saturated, is 5.9x0.935, or 5.51 grains.

As long as the air in the lines does not contain more water vapor per pound than this, there is no danger of clogging due to frost. To secure a safe condition, the 28-lb. air should be cooled to a little less than 22 deg. F. At this temperature the grains per cubic foot are 1.356 and the volume of a pound of air is $V = \frac{53.3 \times 482}{42.7 \times 144} = 4.18$ cu.ft. The grains per pound then equal 4.18x1.356 or 5.62.

This is slightly more than the allowable amount of water vapor and can be reduced by cooling to a slightly lower temperature.

In this case, surface cooling has been assumed. If cooling is by means of a brine spray, the temperature does not need to be lowered as much because a brine spray will reduce the air to somewhat less than a saturated condition due to the salt in the brine. The stronger the brine the higher the temperature may be.

Corvallis, Ore. W. H. MARTIN

Precooling Depends on Final Air Temperature

THE answer to this question depends upon the temperature at which the air is subjected after expansion to 15 lb. pressure. Assuming that the low-pressure air is cooled to 15 deg. F., the dew point must be reduced below this temperature in order to avoid trouble from freezing. The maximum permissible temperature for the high-pressure air can be determined by finding first the vapor pressure of the moisture, as follows:

The ratio of the pressure of water vapor in the saturated compressed air to its pressure in the expanded air will be the same as the ratio of the total absolute pressures. Expressed mathematically, if

P_{V_1} = Absolute pressure of water vapor in high-pressure air

P_{V_2} = Absolute pressure of water vapor in low-pressure air

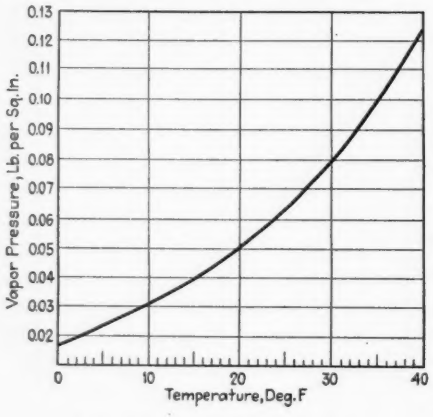
P_{M_1} = Total absolute pressure of mixture of high-pressure air and water vapor

P_{M_2} = Total absolute pressure of mixture of low-pressure air and water vapor

then $\frac{P_{V_1}}{P_{V_2}} = \frac{P_{M_2}}{P_{M_1}}$

or $P_{V_1} = \frac{P_{M_2} \times P_{V_2}}{P_{M_2}}$

Low-pressure steam tables show that a dew point of 15 deg. F. corresponds to a vapor pressure of approximately 0.04 lb.



Vapor pressure of water at low temperatures

per sq. in. (P_{V_2}). Assuming an atmospheric pressure of 14.7 lb. per sq. in. the high- and low-pressure conditions stated in the question are 42.7 lb. and 29.7 lb. per sq. in. abs. respectively. Substituting these values in the equation,

$$P_{V_1} = \frac{42.7 \times 0.04}{29.7} = 0.058 \text{ lb. per. sq. in.}$$

Referring back to the low-pressure steam tables, it is found that a vapor pressure of 0.058 lb. per sq. in. corresponds to a temperature of approximately 23 deg. F. Therefore, the high-pressure air must be cooled below 23 deg. F. to avoid freezing in the low-pressure system at 15 deg. F.

The accompanying curve represents the vapor-pressure data from 0 to 40 deg. F. and may be used to solve this problem for any other combination of pressures and temperatures.

Springfield, Ill. K. M. HOLADAY

Precooling Will Not Prevent Freezing

IF THE agitation air is compressed in an individual machine, there is no reason why the compression should be carried to 28 lb. pressure if the air is used at 15 lb. By changing the air ports, the pressure can be reduced to 15 lb. and in this way not only can some power be saved, but there will be an additional advantage due to the lower temperature of the air.

The temperature to which the air should be precooled does not enter the question at all. There will be condensation and the accompanying trouble in freezing whether or not the air is cooled. The proper drains should be provided and all condensation removed whether or not the air is precooled.

Economically, it pays to cool the air to its original temperature and even lower, provided it can be done without appreciable investment in equipment. If the ice water is precooled, a coil inserted here can serve as the air cooler. Where this is not the case, a length of pipe in some cool spot, as against a raw water pipe, will serve well as the air cooler.

Chicago, Ill. N. T. PEF

How to Clean an Oil-Soaked Floor

Answers to July No. 1 Question

JULY QUESTION

WHAT *is the best and least expensive method of cleaning an oil-soaked, cement basement floor? What treatment should I use to prevent this condition from occurring again?*

A.W.

Used H_2SO_4 and Soap

WE ENCOUNTERED practically the same problem two years ago after oil, that had leaked from one of the turbine bearings seeped under the baseplate and soaked the concrete thoroughly.

Gasoline, pyrene, soda ash and potassium hydroxide were tried, but were unsuccessful. At length the floor was washed with a weak solution of sulphuric acid (10 per cent). It was then gone over with a rag and soapy water. After drying, the floor was given two coats of gray floor enamel. The oil seeped through the paint in one or two places, but it was quickly wiped up and another coat of paint applied. No trace of oil was visible after that, although the floor is walked on daily.

Detroit, Mich. R. BURNS.

Fullers Earth Slow But Cheap

I ASSUME that the oil in question is a mineral oil, in which case scrubbing or soaking with soda ash or caustic soda is of little avail, as mineral oils are not saponifiable.

If the spots are small and the oil has not had time to soak into the concrete, scrubbing with kerosene followed by painters' heavy naptha (as gasoline is too inflammable), will remove a certain amount. But the best and cheapest way is to cover the surface with fuller's earth, which can be bought at any oil refinery at a low price, in case local dealers do not stock in carlots. This method is slow, but cheap and effective, the principle being that fuller's earth has an affinity for oil or grease, taking it up as blotting paper does ink.

Another method is to use magnesium oxychloride, which is made by suspending magnesium oxide (dead burnt magnesite) in a solution of magnesium chloride; this must be prepared as used, as it forms a quick-setting cement which is very durable, and while it does not combine with oil, it forms with it what chemists call a dispersion, as opposed to a true solution.

There are several patented preparations on the market similar to this, being mixtures of magnesium chloride or magnesium fluoro-silicate with other ingredients for which many claims are made, but the fuller's earth method, despite its slowness, is the cheapest. It can be spread on the floor in a thin layer, and as fast as the oil stain appears on the surface, replaced with fresh material. Where the sunlight strikes the floor, sawdust will absorb a great deal of oil. Sunlight has the property of drawing paraffine oil to the surface, as those that have tried to use paraffine oil in paints have learned to their sorrow. Unfortunately, sunlight is not always available.

As to preventing the recurrence of this trouble, it is hard to suggest a remedy without knowing the cause. In general, keep all oil storage in another building, provide drip pans for oil cups and engine beds, etc.; don't flood bearings with oil. Notice the oiling system on a diesel engine, and observe how little oil is needed. Don't leave buckets of oil where they may be easily upset, and don't use makeshift devices for filling oil cups and bearing wells.

St. Louis, Mo. L. R. BAKER.

Use Oxalic Acid and Flour

CLEANING oil from a concrete floor is at best a messy and not very satisfactory job. It is never possible to remove the oil stain entirely, but it is possible to remove enough oil to permit the floor to be painted with any one of a number of paints made specially for use on concrete. Once the floor is painted, any future spilling of oil can be easily mopped up without leaving a stain. The following method of removing oils is used extensively for cleaning garage floors. Dissolve 1 lb. of oxalic acid in 2 gal. of water and add sufficient wheat flour to form a stiff paste. Cover the floor with the paste and allow it to remain for a few days; then scrub it off thoroughly. This mixture contains both a solvent and an absorbent and is usually effective in one application.

New York, N. Y. R. B. RANDALL.

THE ENGINEER'S BOOKSHELF

Vocational Guidance

VOCATIONAL GUIDANCE IN ENGINEERING LINES. *Published by the American Association of Engineers, 8 South Michigan Ave., Chicago, Ill., or Mack Printing Co., Easton, Pa., 560 pages, 50 illustrations. Price $2.50.*

A non-technical explanation by prominent practitioners in various engineering fields of precisely what the practice of their particular branches of engineering entail. This not only includes the nature of the work, but the kind of living it requires, the requisite training, personal qualifications necessary for success and probable compensation to be expected. Charles F. Kettering wrote the chapter on "Automotive Engineering." Robert Ridgway that on "Subway Engineering," L. F. Loree that on "Railroad Engineering." Includes not only major fields, but important specialized subdivisions which have grown up.

Technical Measurements

TECHNISCHE MESSUNGEN (TECHNICAL MEASUREMENTS) — *By A. Gramberg. Published by Julius Springer, Berlin W9, Linkstrasse 23-24. 488 pages, 395 illustrations; Price 24.00 reichsmarks.*

This is the sixth edition, revised and modernized, of a work that first appeared nearly 30 years ago. In general plan, it classifies measurements in terms of quantities to be measured, devoting a chapter to each group: Pressure, time and speed, mass and volume, temperature, quantity of heat, calorimetry of fuels, gas analysis. Measurement of force, torque, work and efficiency have a separate chapter; so has the indicator, 55 pages.

Preceding this detailed treatment, there is a short introduction on units and dimensional quantities in which the author takes occasion to call attention to the distinction between engineering units and those used in physics—meter, kilogram *force*, circuits, against centimeter, gram *mass*, circuits. Thus, transformation involves the gravitational acceleration constant, a point on which the reader is reminded from time to time.

Symmetrical Components

SYMMETRICAL COMPONENTS AS APPLIED TO THE ANALYSIS OF UNBALANCED ELECTRICAL CIRCUITS *(1933). By C. F. Wagner, Research Engineer and R. D. Evans, manager transmission engineering, Westinghouse Electric & Mfg. Co. Published by the McGraw-Hill Book Co., 330 West 42nd St., New York City and London, England. Cloth; 6x9 in.; 437 pages; 218 illustrations; 29 tables; 12-page bibliography. Price $5.*

The solution of unbalanced electrical-circuit problems has been found to be practical only by symmetrical-component method. In this volume is presented the fundamentals of this method as applied to the problems associated with unbalanced short-circuits on power systems. Detailed consideration is given to the determination of apparatus constants required for the method's application, and the work is extended to the consideration of several special problems.

The book is intended to meet the needs of the practicing engineer and engineering student. The authors in the treatment presuppose a knowledge of fundamental single-phase and polyphase circuit theory and the operating characteristics of the more important types of alternating-circuit apparatus. Special attention has been given to working out illustrations of the application of the method used. The problems selected have been drawn principally from those encountered by the authors in their engineering work and should be of special interest to practicing engineers.

Thermodynamics

ELEMENTS OF ENGINEERING THERMODYNAMICS (FIFTH EDITION). *By J. A. Moyer, J. P. Calderwood and A. A. Potter. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. 192 pages, 5¾x9 in. Indexed. 54 diagrams. 11 tables. Appendix and bibliography. Clothboard covers. Price $2.50.*

This fifth edition retains earlier procedure, namely to stress fundamental principles of thermodynamics as a foundation for later more advanced, specialized and practical applications. Many of the changes have grown out of the 1929 conference of mechanical engineering teachers and others are a result of development and standardization. The new material includes the thermodynamic treatment of uniform flow processes and new vapor tables for steam and ammonia. Reversible and irreversible processes are given additional attention and symbols have been changed to conform with those now standard for vapor and other thermodynamic calculations. Steam tables and Mollier diagram provided are adapted from Keenan.

Metal Specifications

STANDARDS AND SPECIFICATIONS FOR METALS AND METAL PRODUCTS (1933). *Compiled by the Bureau of Standards, U. S. Dept. of Commerce. Available from the Superintendent of Documents, Washington, D. C. 1359 pages, 7⅜x10⅜ in. Indexed. Buckram covers. Price $3.*

This volume of the Encyclopedia Series contains standards and specifications for metals and metal products prepared by over eighty nationally recognized organizations authorized to speak for industry or for the Federal government as a whole. Ten chapters. Included are specifications for elevator ropes, pipe, valves, fittings, bolts, rivets, screws, and similar manufactured articles. Some 1,100 illustrations are included, as is a list of technical societies, trade associations and other organizations issuing standards on specifications in these classifications.

BRIEF REVIEWS

HYDRAULIC LABORATORIES IN THE UNITED STATES. *Complete information mimeographed in semi-tabular form, on 63 laboratories in this country, not including ship-model basins except where they are connected with equipment doing work of more general nature. 77 pages. Available from U. S. Department of Commerce, Bureau of Standards, Washington, D. C.*— From the same source can be obtained the "Report on Current Hydraulic Laboratory Research in the United States," dated July 1, second of the quarterly reports on this subject. Gives in tabular form extensive data on all known current research.

BRITISH ENGINE BOILER & ELECTRICAL INSURANCE CO. LTD., *Technical Report for 1932. Available from the company at 24 Fennel St., Manchester, 4, England for 7/6.*—Voluminous report, diagrammed and illustrated, contains details of breakdowns and explosions and further information on boiler welding by L. W. Schuster. This company absorbed Manchester Steam Users' Association during the year.

THE PRODUCTION OF MANUFACTURED ICE AT LOW BRINE TEMPERATURES. *Report of an investigation by the Engineering Experiment Station, University of Illinois, Urbana, Ill. Called Bulletin No. 254. In cooperation with Utilities Research Commission, Inc. Price $0.70.*—Some 66 pages of text results and tabular data, leading to lengthy and detailed conclusions. Limited number of copies available free.

TREATMENT OF WATER FOR ICE MANUFACTURE, PART II. *By Dana Burks, Jr., Published by the Engineering Experiment Station, University of Illinois, Urbana, Ill. Price $0.45. Limited number of copies available free. 34-page bulletin, known as No. 253.*—Further results following those reported in Bulletin No. 219. Detailed conclusions.

METHODS FOR SERVICING NOBLE-METAL THERMOCOUPLES. *By R. S. Bradley, director of research, A. P. Green Fire Brick Co. 6-page Technical Bulletin No. 39 of American Refractories Institute, Pittsburgh, Pa.*—Methods and diagrams.

COAL IN 1931. *Data collected by Bureau of Mines, U. S. Dept. of Commerce. 510 pages, 5¾x9 in. Available from Supt. of Documents, Washington, D. C. Price $0.10.* —All statistics on the coal industry in the U. S.

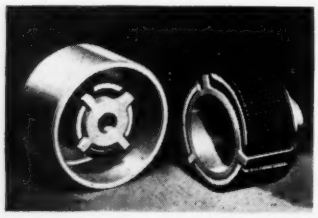
THE CHEMICAL RESISTANCE OF RUBBER AS AN ENGINEERING MATERIAL. *By H. E. Fritz and J. R. Hoover, B. F. Goodrich Co. 17 pages, 5¼x8½ in. Published by The B. F. Goodrich Co., Akron, Ohio.*— A reprint of the A.S.T.M. paper of the same name in the Symposium on Rubber last year.

WHAT'S NEW IN PLANT EQUIPMENT

2-in. Indicating Gage

Moderate priced, this Model DH gage still has guaranteed accuracy and full-length 270-deg. scale. Designed so that it uses full-length Bourdon spring and gives accuracy within 1 per cent of its total scale. Drawn-brass case, with nickel, brass or chromium finish. Connection on top, bottom or either side. Any range from 0-15 lb. per sq.in. to 0-300, as well as 0-30-in. vacuum, available.

The Foxboro Company, Foxboro, Mass.



Four-Duty Coupling

Falk-Rawson 4-duty coupling starts, couples, cushions and limits load. Essentially it is two drum-shaped members, one on driving shaft, one on driven. Between driving and driven shafts are two sets of floating segments, made usually of brake lining reinforced with lead, amount of lead being calculated to give required centrifugal pressure for carrying load. Outer segments are actuated by driving member and inner by driven member. Complete data in Bulletin 500.

The Falk Corporation, Milwaukee, Wis.

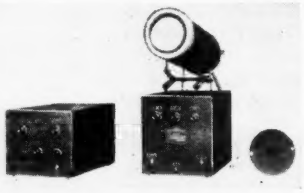
Light-Weight Welding Fittings

Steel fittings for light wall piping and Taylor spiral pipe are included in these fittings welded from No. 10 gage (0.134-in.) steel. Die-formed for smoothness; center-to-end dimensions conform with 125-lb. American Standard. Plain end or flanged, or flanged one end only. Attached flanges are forged steel. Suitable for hydraulic pressures up to 200 lb. per sq.in. or more on smaller sizes. Tested to 50 per cent more than ordered working pressure. Inside diameters, 3, 4, 5, 6, 8, 10, 12, 14, and 16 in.

Taylor Forge & Pipe Works, P.O. Box 485, Chicago, Ill.

Cathode-Ray Oscillograph

Type HG-10-B1 cathode-ray oscillograph is low price, quality instrument for study of recurring waves from power frequencies to several million



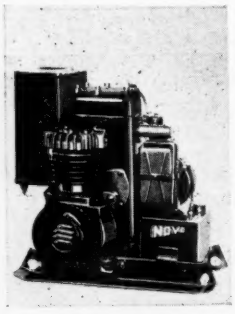
cycles per second. High degree of portability and unit is readily adaptable to switchboard mounting or classroom demonstration. Complete oscillograph requires only 200 watts, and can be operated by any 110-volt, 50 or 60-cycle source.

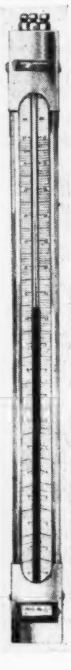
General Electric Co., Schenectady, N. Y.

Engine-driven Compressor for Engine Starting

Especially adaptable for oil and gas engine starting, this compact units operates by automatic impulse coupling on engine. Vertical automotive type, with roller-bearing crankshaft and moisture-proof magneto. Radiator or hopper cooling, independent unit, or cooled from city water supply. Available to run on gasoline or natural gas. Compressor of vertical or angle type, air-cooled, with roller or ball bearings. Single- or two-stage type with counterbalanced crankshaft. Angle-type units have replaceable cylinders. Crankcases dustproof. Monobloc-type drive compressor built integral with engine, or engine with V-belt close-coupled drive.

Novo Engine Co., Lansing, Mich.

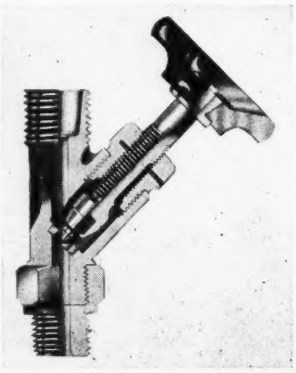




Novo engine-compressor above; Uehling depth gage right.

Indicator Valve for Diesel Engines

Maihak double-seated valve has body designed to provide straight passage through, with plug out of passageway when valve is open. When closed, pressure on indicator is released to atmosphere through vent hole in bonnet. When open, beveled collar on spindle makes



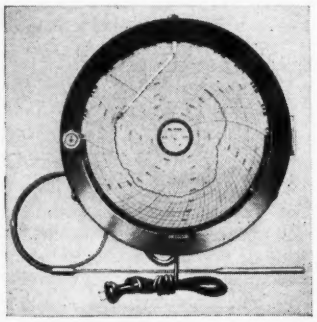
tight contact with beveled surface on bonnet. Plug and seat ring heat-resisting steel; body, bonnet and spindle bronze. V-shaped body lessens mounting space required, and handwheel, at 45 deg., is right at indicator. Simple valve. Bulletin 1267.

Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

Depth Gage (left)

"Tank-O-Meter" depth gage, Type V, gives accurate measurement of tank contents. Supplied in 24 models for measuring liquid depths from 12 in. to 675 in. Can be calibrated in depths, units of weight, or units of volume. Three indicating fluids of different specific gravities to suit various conditions, thus giving scales of various lengths in proportion to depth to be measured. Chromium-plated unit.

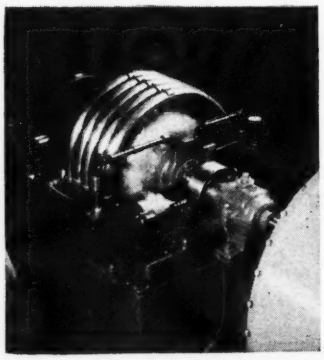
Uehling Instrument Co., 473 Getty Ave., Paterson, N. J.



Recording Thermometer

This line of 8- and 12-in. circular-chart instruments includes thermometers in indicating and recording types for temperatures from—40 to 1,200 deg. F., and indicating or recording pressure and vacuum gages for ranges of 10 in. of water to 5,000 lb. All types in 1, 2 or 3-pen models. In thermometers, mercury-filled Bourdon tubes improved; now built of special stainless steel that takes 100 per cent overload. Gas- and vapor-type Bourdon tubes heat treated phosphor bronze. Thermometers can be 200 ft. away. Three different types of actuating movements used in pressure and vacuum gages. For ranges of 10 in. water to 30 lb., flexible metal diaphragm; 30 to 200 lb., spring-opposed bellows; over 200 lb., helix (Bourdon tube). Electric clock or hand-winding optional.

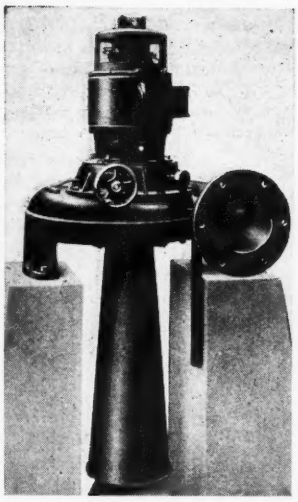
Brown Instrument Co., Philadelphia, Pa.



Hydraulic Coupling

This coupling makes possible variable-speed control with constant-speed driver and is developed for use with centrifugal pumps. Simple induction motor operates it instead of usual slip-ring motor. Gives exact speed required for any discharge without losses inherent with slip-ring motor or when discharge is controlled by throttling. Unit shown delivers 130 hp. at 3,600 r.p.m.

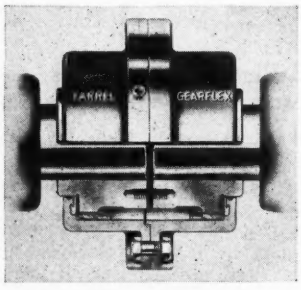
American Blower Corp., Detroit, Mich.



Small Standby Hydro-Electric Unit

Water-turbine-generator unit for standby lighting service for power and manufacturing plants where reasonable water pressure is available. Turbines of vertical-shaft type with spiral cases, movable gates, but may be had with a horizontal shaft. Generators standard, 125- or 250-volt, compound-wound, constant-voltage type. Manual adjustment facilitates water economy, but governors can be furnished for completely automatic operation. Water turbines, without generator, also offered for starting gas or gasoline engines, for driving pumps and compressors, for driving machinery where electric motors would be hazardous, and waterworks service for chlorinating pumps. Capacities ½-80 hp.

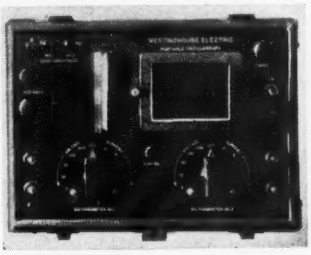
J. M. Voith Co., Inc., 723 Chrysler Bldg., New York City.



Gear-Type Flexible Coupling

"Gearflex" coupling of double-engagement type illustrated consists essentially of two externally geared hubs keyed to shafts to be connected and engaging an internally geared sleeve encasing them. With two sets of spur gears, one at each end of floating sleeve, misalignment is compensated for by sleeve assuming neutral position between shafts. Reservoir between hubs and floating sleeve carries lubricant, which is thrown outward to lubricate gear teeth as coupling revolves. Unit also made in single-engagement type with only one externally geared hub in engagement with an internal gear in sleeve, other hub being solid with sleeve bolted to it. This provides lower-cost coupling where high speed capacity and high flexibility are not required.

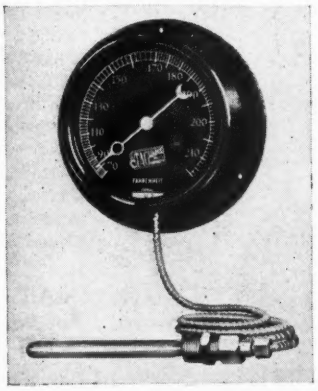
Farrel-Birmingham Co., Inc., 344 Vulcan St., Buffalo, N. Y.



Portable Oscillograph

Differing greatly from previous designs, this unit uses new type of optical system and galvanometer. May be used as conveniently as voltmeter or ammeter. Is entirely self-contained and may be operated from 110-volt, 60-cycle circuit without auxiliary attachments. Compact, over-all dimensions being 8x11½x11 in. Total weight, 18 lb. Meets a variety of general engineering applications.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.



5-in. Dial Thermometer

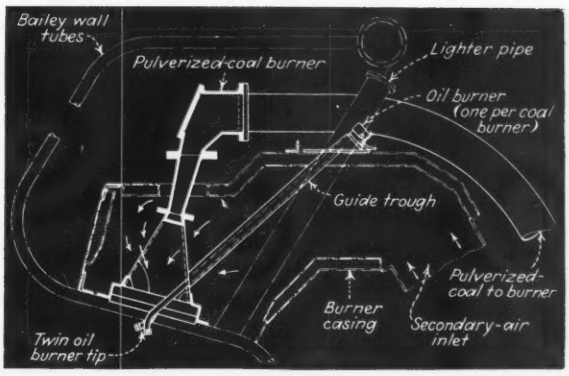
Low-price 5-in. instrument with black Bakelite case and element suited to commonly used vapor tension ranges between —40 and +335 deg. F. Indicating pointer actuated by motion of a bronze bellows through vibration - proof connecting mechanism. Bulletin 1050.

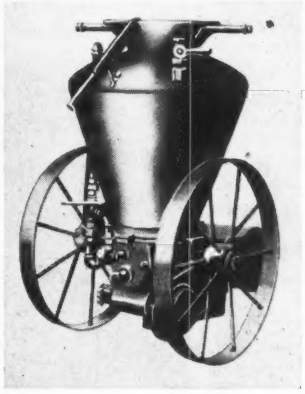
C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

Combination Coal-and-Oil Burners for Water-Cooled Furnaces

Combination pulverized coal and oil burner suitable for furnaces with water-cooled walls. Pulverized coal burner is standard multiple-intertube burner. Oil burner is twin-nozzle type and is inserted between two tubes in front of pulverized-coal burner, extending back and through burner casing, supported by a guide trough between casing and burner tip.

Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.





Compressed-Air Type Refractory Applicator

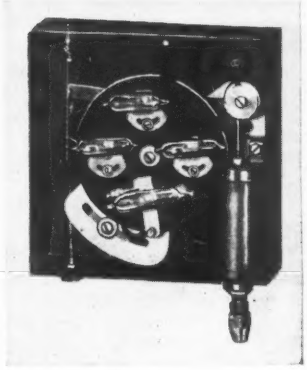
"Gunitor" applies concrete, cement-sand mixtures and refractories pneumatically. New line of lighter, smaller units includes one-man type operated by motor and with electrical remote control. Other new types include Combine-Gunitor with gasoline engine, air compressor, water pump and Gunitor on same chassis. Capacities range from 40 cu.ft. per hr. to 250.

The Gunitor Co., Elkhart, Ind.

Rotary Pressure Switch

Heavy-duty pressure switch for control of single or multiple pumps, air compressors, electric valves, alarms or signals. One unit operates multiple electrical circuits. Principle that of springless scale; pressure changes push up counterweighted lever that tilts disk bearing required number of mercoid switches set to desired angles. Can make or break up to six circuits in any desired sequence. Capable of carrying large mercury switches for heavy currents. Easily set for pressures and close or wide differentials while in operation. Standard capacities, 0-10, 50, 100 and 200 lb.

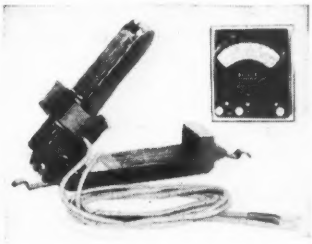
Water Level Controls Co., 765 Hampden Ave., St. Paul, Minn.



High-Temperature Spring Material

Bronze springs lose load-carrying capacity at 200-250 deg. F., carbon steel at 300-350, chrome-vanadium alloy springs at about 400 deg. F. New springs of Inconel high-nickel stainless alloy (80% nickel, 14% chromium, 6% iron) retain load-carrying capacity to 700 deg. F. (fibre stress 65,000 lb. per sq.in.)

International Nickel Co., 67 Wall St., New York City.



Test Set

Type CSO split-core transformer test set with Type PA or "Steel-Six" Portable ammeter will give a.c. readings as low as 0.5 amp. and as high as 200 amp. Ammeter, designed especially for use with this transformer, may however be used separately as self-contained double-range ammeter. Two ranges in ammeter, 2.8 amp. and 15, without transformer. With transformer, ranges 40 and 200 amp. Not necessary to open circuit to use test set.

Roller-Smith Co., 233 Broadway, New York City.

POWER LINES

BUFFALO GREETS N.A.P.E.

Aug. 28 delegates from all parts of the United States assembled in Buffalo, N. Y., for the national convention, in conjunction with which was held the Niagara Frontier Power Conference and Exhibit. Both convention and power show were held in the great Broadway Auditorium. The show was backed not only by the local and national N.A.P.E., but also by local sections of many engineering bodies, including: American Society of Mechanical Engineers, American Society of Civil Engineers, American Institute of Electrical Engineers, Engineering Society of Buffalo, Illuminating Engineers Society, American Welding Society, American Society of Heating and Ventilating Engineers, Society of Automotive Engineers.

The technical papers presented at the convention include: "Air Conditioning in Relation to Public Utilities," by Willis H. Carrier; "Survey of Refrigeration Processes," by David L. Fisk, executive secretary of the American Society of Refrigerating Engineers; "Recent Developments in Steam-Generating Equipment," by Henry B. Jones of Babcock & Wilcox; "Modern Diesel Engine Practice," by A. Boehm of Worthington Pump & Machinery Corp.; "Maintenance of Wire Ropes," by F. S. Burtch of Roebling. A joint banquet was held Aug. 29 with electrical demonstrations, also an exhibitors' entertainment Aug. 30. Election of officers was held Sept. 1, too late for *Power* to include in this number. An inspection trip Aug. 30 covered the H. P. Huntley power station.

Oil and Gas Power Meeting Held at Atlantic City

For the first time in several years, the Oil & Gas Power Division of the A.S.M.E. held its annual meeting at other than State College, Pa., choosing instead the Ritz-Carlton Hotel at Atlantic City, N. J. Although the 3½-day meeting began inauspiciously during the visit of the worst storm in that area in 40 years, attendance was surprisingly good, and built up gradually during the sessions. Several elements of the program were outstanding, most of them unscheduled, one being the extensive discussion of the paper by Everett Chapman of Lukenweld, Inc. (pages 479-481, this number).

During several days, Mr. Chapman, P. B. Jackson of Aluminum Co. of America and Ralph Miller, chief engineer of Ingersoll-Rand Co., engaged in a discussion regarding respective merits of welded steel and aluminum for light frames for diesel engines. Although aluminum is only one-third as heavy as steel, it is only one-third as stiff. Mr. Chapman brought out that this factor might cause difficulty in cases where an engine was to be built with given size limitations. Mr. Miller and Mr. Jackson brought out that aluminum frames already constructed have been lighter, size for size, than known built welded frames, though their cost runs somewhat more. Mr. Chapman held that for maximum stiffness and resistance to repeated impact, welded steel frames could not be beaten, but his opponents explained that only 15 to 20 per cent of a diesel frame is subjected to such stresses, the remainder being purely filler material. Mr. Chapman brought out also the more familiar advantages of steel welding, namely one-at-a-time production at comparatively low cost, no necessity for patterns or pattern storage, dependability of welded frames, etc.

Another event of importance was the address of Edward B. Pollister, president of Busch-Sulzer Bros. Diesel Engine Co., at the banquet. Discussing "Sea Power and the Diesel Engine," Mr. Pollister gave a non-technical discussion of the relative position of the American navy and explained how building of new ships with diesels would increase their operating range, speed, and general effectiveness.

Corrosion problems, due to gases being cooled below the dew point, have always been serious with air preheaters. The photograph shows a new trend in this field—use of wrought-iron tubes instead of steel. The picture was taken in Crawford Ave. Station of Commonwealth Edison Co. of Chicago. The wrought-iron tubes are 3 in. O.D. and 12 gage. Though there were 443 tubes in this installation, all were installed without a crack or a failure

At the technical sessions, the following papers were presented: Welded-Steel Diesels, Causes and Effects of Pressure Waves in Fuel-Injection Systems, Reducing Engine Performance to Standard Conditions, Scavenging and Supercharging 2-Cycle Diesels, Compression-Ignition Tests With a Sleeve-Valve Engine, Low-Compression Spark-Ignition Oil Engines. The annual report on Oil & Gas Engine Power Costs was also presented.

While only a few exhibits were included, they were uniformly well chosen and of distinct interest to those attending.

Combustion Engineering Reorganized Aug. 1

In accordance with the preliminary announcement of reorganization in *Power* for Aug. 1, 1933, Combustion Engineering Co., Inc., a newly organized company, took over the properties of International Combustion Engineering Corp., and affiliated companies recently sold by order of the Federal Court. The properties acquired include those of Combustion Engineering Corp., Hedges-Walsh-Weidner Co., Coshocton Iron Co., and Raymond Bros. Impact Pulverizer Co. The new company will continue Combustion Engineering Corp.'s complete line of fuel-burning, steam-generating and related equipment.

This company's installations in recent years include such projects as the largest steam-generating units in the world (New York Edison Company), the highest-pressure steam-generating units in commercial operation in the country (Philip Carey Company), the largest high-pressure steam-generating units in the central station field (The Milwaukee Electric Railway & Light Co.) and the largest high-pressure boilers in the industrial field (Ford Motor Company).

N.A.P.R.E. Plans Convention For New Orleans in November

The National Association of Practical Refrigerating Engineers will hold its 24th Annual Convention and Educational Exhibition at the Roosevelt Hotel, New Orleans, La., Nov. 8-11. The Convention Program Committee is under chairmanship of Edwin S. Libby, professor of refrigeration at Armour Institute of Technology, Chicago. An extensive exhibition of refrigeration machinery, engine room equipment and supplies will be conducted during the convention. Complete information from Edward H. Fox, National Secretary, 435 North Waller Ave., Chicago, Ill.

Pittsburgh Testing Lab Forms National Weld Testing Bureau

Pittsburgh Testing Laboratory, which maintains laboratories, branches or personnel in the principal industrial centers of the country, has organized a welding division to be known as its National Weld Testing Bureau. This division will be headed by James W. Owens, well-known welding engineer, as director. The Bureau proposes to render a complete welding service.

MANY SOCIETIES PLAN FALL MEETINGS

A number of societies and organizations having members from the power field are planning Fall conventions and exhibitions. These include the American Welding Society, National Safety Congress, 14th Exposition of the Chemical Industries, Ass'n of Iron & Steel Electrical Engineers, and American Chemical Society.

The A.W.S. meeting is to be held Oct. 2-6 at the Book-Cadillac Hotel, Detroit, with papers on Gas-Cutting of Structural Steel, Impact Resistance of Welded Joints, Heat-Resisting and Stainless Alloys, Manufacture of Small Everdur Tanks by Welding, Welding Chrome Alloy Steels and Oxygen Free Copper, Gas-welding Aluminum, Welding Non-Ferrous Metals and Alloy Steel, Atomic-Hydrogen Welded Tubing, Physical Properties of Welded Cast Steel, Arc-Welding Under Water, Fatigue of Metals, Continuous Seam Welding of Pressure Vessels, Welding Structural Nickel Steel and Galvanized Steel, Use of Shielded Carbon Arc in Class I Welding, and a number of other papers less closely identified with the power field. The usual banquets and social events are included.

During the same period, Oct. 2-6, the National Safety Congress will be in session at the Stevens Hotel, Chicago. There will be over 100 program sessions, representing about 40 different organized groups interested in various phases of the safety movement including 23 cooperative industrial sections of the National Safety Council. More than 350 speakers are scheduled.

W. T. Read, dean of the School of Chemistry, Rutgers University, will direct the program of student courses at the 14th Exposition of the Chemical Industries in Grand Central Palace, New York, Dec. 4-9. During the Exposition week, the A.S.M.E. will be holding its annual meeting in New York, so that well over the 100,000 visitors at the last Exposition are expected to attend this one.

American Chemical Society will hold its Chicago meeting from Sept. 10-15. at the Stevens. Included in the program of the Division of Gas and Fuel Chemistry are papers on "25 Years' Progress in Gas and Fuel Chemistry" (symposium), Coal Classification, Natural and Refinery Gases, Coal Carbonization, Gas Making and By-Product Recovery, Low Rank Coals and many other papers of power interest.

Formulation of the program for the 29th convention of the Association of Iron and Steel Electrical Engineers in Pittsburgh, Pa., Oct. 17 to 19, indicates that some power topics will receive major consideration.

New Standards

Standards for Constant-Current Transformers, Moving-Coil Type (C57.1-1933) have been approved by American Standards Association as American Standard. These standards were submitted for approval by the A.I.E.E. and comprise a revision of A.I.E.E. standard No. 12. The Association has also approved Standard Specifications for Code Rubber Insulation for Wires and Cables for General Purposes (C8.11-1933) as American Standard.

A new subcommittee on Nomenclature of the Sectional Committee on Classification of Coal (M20) has been appointed. The subcommittee, appointed by A. C. Fieldner, chairman of the sectional committee, is: E. A. Holbrook, *chairman,* C. H. Ashley, H. N. Eavenson, W. H. Fulweiler, T. W. Harris, Jr., T. A. Hendricks, M. M. Leighton, H. J. Rose, E. Stansfield, F. R. Wadleigh.

Welding Now Approved For Boiler Repairs

Ever since welding has been used, and even since its approval as a method of fabricating boilers and pressure vessels, it has been taboo as a means of boiler repair in cities and states under the A.S.M.E. Boiler Code, which does not cover repairs. Consequently, it has long been felt that some Code covering repair should be adopted. The National Board of Boiler & Pressure Vessel Inspectors, cooperating with the National Bureau of Casualty & Surety Underwriters, has worked out such a code, and it has just been accepted by the A.S.M.E. Boiler Code Committee as agreeing with the elements of the Code itself. Essentially, fusion welding is now allowed for repair of boilers and pressure vessels where such controlled welding as permitted by the A.S.M.E. Code is used.

This, in fact, means that if a repair is to be effected by welding, say on a Class 2 pressure vessel, the welder doing the repair work must be qualified in accordance with the requirements for the qualification of welders engaged in the *construction* of Class 2 pressure vessels as laid down by the A.S.M.E. Pressure Vessel Code. Or, if the vessel is a Class I pressure vessel, the welder must be qualified in accordance with the requirements for Class 1 *construction.*

New York Stores Ready To Run Private Plants

Grover A. Whalen, general manager of John Wanamaker, New York, appearing Aug. 3 before the Public Service Commission as spokesman for large New York department stores consuming together more than 40,000,000 kw.-hr. of electric energy at a cost of almost $1,000,000 a year, said that unless temporary rate reductions were granted promptly, his own store and several other stores would install their own electric light plants.

P.E.C.U. Plans to Extend Employment of Engineers

Believing that during the years of prosperity the professional engineer has lost or forgotten his ability to find a job for himself, the Professional Engineers Committee on Unemployment is proposing a new committee involving selection of one engineer from each industry or branch of the profession to organize a committee within the industry to study that industry to discover opportunities for engineering usefulness. Such a list with the necessary accompanying arguments to employers will be forwarded to the P.E.C.U. who will then notify properly qualified engineers to study the industry and prepare in writing a definite statement of the service that the individual engineer can render the proposed employer. While the engineers are engaged in this activity, the P.E.C.U. will endeavor to convince the prospective employer of the need of an engineer to assist him. Organizations will begin with one industry which will be covered nationwide before other organization is begun.

Stoker Manufacturers Hold Annual Meeting

The Annual Meeting of the Stoker Manufacturers' Association was held at the Palmer House, Chicago, July 24 and 25. Officers for the coming year are: W. H. Rea, Detroit, president of the Detroit Stoker Co., *president;* J. R. Whitehead, manager Stoker Division and Research Department, Fairbanks, Morse & Co., Chicago, *vice-president;* Harry H. Kurtz, branch manager, Iron Fireman Mfg. Co., Chicago, *treasurer;* and Marc G. Bluth, Chicago, *secretary.* A number of new members have joined the Association, and it has adopted an NRA code for the Stoker Industry. Headquarters are at 307 North Michigan Ave., Chicago.

Public Interest to Dominate Tennessee Policy

In its guiding policy, recently announced, the Tennessee Valley Authority stresses the public over private interests. Following are excerpts:

"The interest of the public in the widest possible use of power is superior to any private interest. Where the private interest and this public interest conflict, the public interest must prevail . . .

"The right of a community to own and operate its own electric plant is undeniable. This is one of the measures which the people may properly take to protect themselves against unreasonable rates. Such a course of action may take the form of acquiring the existing plant, or setting up a competing plant, as circumstances may dictate . . .

"Accounting should show detail of costs, and permit of comparison of operations with privately owned plants, to supply a 'yardstick' and an incentive to both private and public managers."

OBITUARIES

Mrs. Harvey N. Davis, wife of the president of Stevens Institute of Technology, was killed recently by an automobile which hit her while cycling on Long Island.

Patrick J. Cooney, 80, for many years engineer of the Lebanon Mills, Pawtucket, R. I., died at his home there July 21. He retired four years ago.

Wyllys Edmund Dowd, Jr., 64, vice-president of Foster-Wheeler Corp., 165 Broadway, New York, died Aug. 14 at his home in Greenwich, Conn.

Walter H. Goff, 69, for the past

seventeen years engineer at Rhode Island School of Design, Providence, R. I., died at the Rhode Island Hospital Aug. 10, after a 7-week illness.

PERSONALS

WILLIAM T. CONLON of Superheater Co., 60 East 42nd St., New York, has been appointed manager of its Industrial Department. In this capacity he will have charge of the design, manufacture and sale of Elesco superheaters and other equipment for all types and makes of boilers for public utility and industrial power plants. He has been with the company in an executive sales capacity since 1929.

JOHN C. COSGROVE, Johnstown, Pa., chairman, Technical Research Section of the National Coal Assn., and president of West Va. Coal & Coke Co., has been elected chairman for the ensuing year of the Committee of Ten, Coal & Heating Industries. Other officers were reelected.

DR. JEROME CLARKE HUNSAKER has been appointed head of the department of mechanical engineering at Massachusetts Institute of Technology, to succeed the late Prof. Edward F. Miller. Dr. Hunsaker, formerly vice-president of Goodyear-Zeppelin Corp., is internationally known for his contributions to aeronautical engineering.

HARRY S. ROGERS, since 1927 dean of the school of engineering, Oregon State College, Corvallis, has resigned to become president of the Brooklyn Polytechnic Institute, Brooklyn, N. Y. Dean Rogers came to Oregon State in 1920 from the University of Washington as professor of hydraulic engineering.

CHARLES H. GARITY of Catonsville, Md., has been appointed Director of Purchases and Procurement by the Tennessee Valley Authority. Mr. Garity has had wide experience in the hardware, mill supplies and general machinery line. He has recently been connected with the Arundel Corporation of Baltimore on the Safe Harbor hydro-electric project as purchasing agent and office manager.

GEORGE QUINT has joined the Refractories Division of the M. W. Kellogg Co., 225 Broadway, New York, N. Y., and will have the Metropolitan New York Territory.

WILLIAM W. MOORE, formerly of the Chicago office of Detroit Stoker Co., has been appointed southern representative of the company, with headquarters in Atlanta, Ga.

W. R. WOOD, for 15 years with Green Engineering Co. and its successor, Combustion Engineering Corp., has joined the sales staff of Whiting Corp., Harvey, Ill.

WM. CRAIG WOLFE has been appointed vice-president in charge of sales for Reading Iron Co., Philadelphia. He was formerly general manager of Highland Iron & Steel Co.

BUSINESS NOTES

GENERAL ELECTRIC Co., and four of its associated companies have removed their offices in New York to the new General Electric Bldg., 570 Lexington Ave. at 41st St.

EDWIN BURHORN Co., cooling tower manufacturer since 1900, has moved from Bayonne, N. J., to No. 1 Newark St., Hoboken, N. J.

WORTHINGTON PUMP & MACHINERY CORP., Harrison, N. J., has appointed Kroeschell Engineering Co., 2306 North Knox Ave., Chicago, as dealer in that area for Worthington refrigerating equipment.

FISHER GOVERNOR Co., Marshalltown, Ia., has announced appointment of M. N. Dannenbaum Co., 304 Shell Bldg., Houston, Tex., as direct factory representative in southern and eastern Texas.

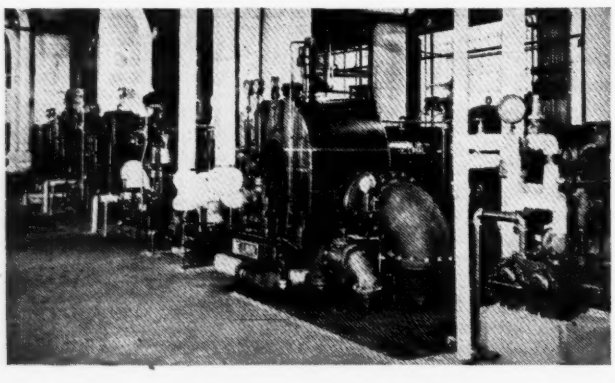
ASHTON VALVE Co., 161-179 First St., Cambridge, Boston, Mass., has recently appointed C. B. Burgoyne, 408 North 23rd St,. Birmingham, Ala., as agent for Alabama.

POOLE FOUNDRY & MACHINE Co., Baltimore, Md., has appointed McVoy-Hausman Co., Brown-Marx Bldg., Birmingham, as representative in Alabama.

STRAWS

Pointing the way the business wind blows

Several Iowa municipalities are arranging plans and financing for new municipal electric light and power plants. Wapello citizens have authorized Common Council to proceed with construction of municipal generating station to cost $107,000, and plans are being completed by H. L. Cory Co., Baum Bldg., Omaha, Neb. Similarly, Common Council at Wellman has been authorized to build plant to cost $85,000, with equipment, and Council at Morning Sun has secured authority of citizens to arrange a program for a municipal power station costing $70,000. At Keokuk, proposition is under advisement for a municipal electric light and power project to cost $1,250,000, with equipment and distribution facilities. Missouri Valley proposes to expend $35,000 for new generating unit and auxiliary equipment for power service, including electric-operated pumping machinery and reservoir for water service. Alta Vista and Dunkerton plan construction of new transmission lines for high-tension power supply. Winfield has plans for electric light and power plant to cost $65,000, for which Young & Stanley, Inc., Muscatine, Iowa, are consulting engineers. Manning is considering municipal power station to cost $135,000 with equipment. At Anita, an electric lighting plant and new city hall are projected, at estimated cost of $150,000. Coon Rapids has tentative plans for a municipal electric plant costing about $90,000. Woodbine proposes an electric light and power plant, as well as a new city hall, to cost over $100,000.



Four new DeLaval turbines in the plant of American Chicle Co. at Long Island City, N. Y. Two largest are 550 hp. each, one is 335 hp., and smallest is 200 hp. One 550-hp. turbine has a Foster-Wheeler condenser in connection with a roof cooling tower

Borough Councils at Arnold and New Kensington, Pa., are projecting plans for municipal electric light and power plant to be owned jointly by the two communities, with transmission and distributing lines for commercial service at both places.

Eureka, Calif., has authorized plans for a hydro-electric power development on Mad River, including power dam, generating station, transmission lines and power substations. It is estimated to cost about $1,200,000. City is also planning a municipal water supply program, with pumping stations, pipe lines, etc., to cost approximately $375,000. C. C. Kennedy, 74 New Montgomery St., San Francisco, is engineer for both projects.

Bureau of Reclamation, Denver, Colo., W. F. Walter, chief engineer, is beginning plans and engineering work for the proposed Grand Coulee Dam and hydro-electric power project of the Federal Government on the Columbia River, vicinity of Coulee City, Wash., for which an initial appropriation of $63,000,000 has been authorized. Engineering headquarters will soon be established at Almira, Wash., about 22 mi. from damsite, or neighboring town, with Frank A. Banks of the Bureau, as engineer in charge. The first unit of the power dam will be about 146 ft. high, and is estimated to cost $40,097,331; the final dam unit, as now projected, will be 355 ft. above low water. The first dam will create a lake in the river about 50 mi. long, reaching to a point in the vicinity of Fruitland, Wash.; the ultimate power dam will create a lake over 100 mi. in length. The initial power plant will consist of two units, estimated to cost over $8,000,000, divided as follows: high-pressure hydraulically operated sluice gates, metal conduit linings, railroad, cranes, etc., $1,706,000; power house buildings, control structures and facilities, and switching structure, $2,455,000; power plant, switching station and control equipment, with complete accessories, $2,663,000. Plant units will have a rating of 65,000 kw. each; ultimate station is designed to have eight such generating units, with total cost of $19,138,000. The project will include an extensive steel-tower transmission system.

It is proposed to complete preliminary engineering work this fall, and to proceed actively with the program immediately thereafter. The State of Washington has provided a fund of $377,000 for the engineering work.

Ogden, Utah, is planning a municipal power plant.

Detroit Edison Co. is having two 20,000 kw. and two 30,000 kw. (200 lb., 588 deg.) outmoded turbine generators modernized by General Electric. The two 30,000 kw. generators, and other parts are being retained in modernization to 600 lb. and 825 deg. No foundation changes are required.

Belleville, Ill., is planning a $1,600,000 municipal water plant and small electric light plant, expecting a $2,000,000 Federal loan.

St. Charles, Mo., is trying to borrow $350,000 from the Government to finance a diesel light and power plant. Citizens twice voted down a bond issue.

East Liverpool, Ohio, has received a report from Loftus & Shover, engineers of Pittsburgh, on proposed municipal light plant. System to cost $1,251,891 they claim would reduce rates 10 per cent. Vote called for Nov. 7 on bond issue.

Two Rivers, Wis., has applied for a Federal loan to finance a $240,000 municipal light and power plant.

R. H. Macy & Co., New York City, brought its new 1,000-kw. mixed-pressure turbine generator (*Power*, May, 1933, page 225) to load shortly after the middle of last month and has been operating the new roof cooling towers for the past month. Three of the five are for air-conditioning service, the other two for the new turbine.

Kennett, Mo., has authorized bond issue of $140,000 for municipal electric light and power plant (diesel) and distributing system. Purchase of equipment scheduled at early date. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., consulting engineer.

A $500,000 municipal power program is planned by Compton, Calif., J. H. Park, city manager, and arrangements for financing will be made at early date. Of this amount, one-half will be used for a municipal electric light and power plant, while other half, or $250,000, will be utilized for construction of a municipal gas plant and distribution system.

Sandusky, Ohio, will vote on a bond issue of $1,400,000 at the forthcoming general election, the fund to be used for construction of a municipal electric light and power plant. C. Webb Sadler, city manager, in charge.

Among new diesel stations planned are Flandreau, S. D. (consultant to be appointed); Mountain Lake, Minn. (investigation; St. Charles, Minn. (Survey completed by Druac & Milinowski, St. Paul); El Paso, Tex. (block power plant study); Granite City, Ill., (Caldwell Engineering Co., Jacksonville, Ill., making survey); Knickerbocker building development in New York (plant for light and power in apartment development); Monmouth, Ore. (preliminary survey); Rockford, Ia. (Contract awarded Fairbanks-Morse for municipal light and power plant). Madison, S. D., is adding a 38x53-ft. addition for engines to be purchased.

New hydro-electric plant at Grand Forks, B. C., which completed its first year of operation July 31, showed a profit of $3,538.14 for the 12-mo. period, after allowing for deduction of depreciation and production costs. The plant is municipally owned and was built by Yuill & Knight, hydro-electric engineers, Vancouver, B. C.

Schwartz Brewing Co., Corpus Christi, Tex., plans brewing plant, with power house, refrigerating plant, etc. Estimated cost $400,000.

At special election, Grundy Center, Iowa, has authorized fund of $120,000 for new city-owned electric light and power plant.

Plans approved by Fox Paper Co., Lockland, Ohio, for steam-electric generating plant for paper-mill service. Cost about $100,000.

Department of Interior, Washington, D. C., has secured an appropriation of $460,000 for steam-electric power plant at Howard University.

Until Sept. 12, Bureau of Reclamation, Denver, Colo., asks bids for two 3,500-hp. horizontal-shaft, double-overhung, impulse-type, hydraulic turbines, complete with auxiliary equipment, also for two 3,000-kva., a.c. generators for Boulder power plant, Boulder City, Nev. (Specification 545).

Contract for installation of new Dominion Experimental Station pumping system at West Summerland, B. C., has been placed with Pacific Pipe & Flume, Ltd., Penticton, on a tender of $20,400. Amended specifications provide for one multiple-stage pump on lower pump house, and three 50-kva. transformers and three 15-kva. transformers. Contract also involves laying 3,000 ft. of welded-steel pipe and installation of electrical pumping equipment. R. A. Barton, Penticton, engineer.

Lukenweld, Inc., division of Lukens Steel Co., Coatesville, Pa., has been awarded the contract by Winton Engine Corp., Cleveland, Ohio, for the manufacture, in arc-welded rolled steel construction, of the complete engine structure for the 600-hp. 12-cyl., V-type Winton engine which will power the new 110-m.p.h. light-weight passenger train of Union Pacific.

The governments of Rumania and Yugoslavia are planning joint action in erection of an immense hydro-electric plant and canals at Orsova, on the international boundary. About 750,000 hp. can be developed there at a cost of about £7 million. Electrification of railroads and intensifications of industry in both countries is the goal, with improved shipping facilities on the Danube.

Fortville, Ind., is planning a municipal plant. Tipton, Ind., city council has voted to install a lighting plant, to cost $180,000.

Since the date of its opening the hydro-electric power station on Dnieper River, U.S.S.R., has supplied 300,000,000 kw.-hr. This power house supplies energy to the metallurgical plants of Dniepropetrovak, Kamensk, Zaporozhye, the "Kommunar" plant.

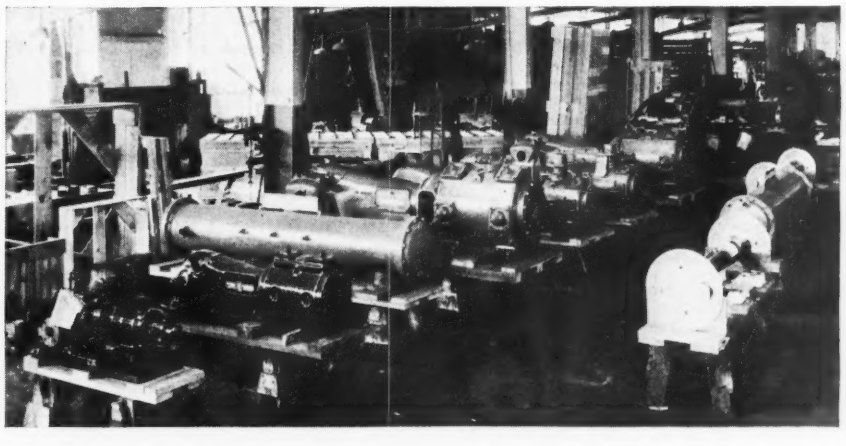
Arrangements for installation of a 200-hp., two-engine, diesel power plant at Smithers, B. C., were recently completed by F. J. Bartholemew and Leith Murray of Vancouver, B. C., directors of Columbia Power Co., Ltd.

Returning prosperity may not prove an unmitigated blessing, according to findings of David R. Morris, meteorologist of the Weather Bureau Observatory in Central Park, New York City, whose latest report on atmospheric pollution during July affirms that the steady gain in pollution since March "is likely due to increased industrial activity."

A $2,500,000 pipe line project is planned by Michigan Natural Gas Corp., Mount Pleasant, Mich., from gas fields near Broomfield, Mich., to Bay City, Saginaw, Pontiac, Flint, Mich., and vicinity, a total distance of more than 150 miles.

A special stoker suitable for burning a mixture of coal and tan bark in the proportions of approximately 75 per and 25 per cent has been purchased by Ashtabula Hide & Leather Co. from Westinghouse. This unit, together with its boiler, is part of a rehabilitation plan which the leather company is working on at the present time and is the second of its type purchased by that company. The original stoker was designed for this particular fuel requirement and functioned effectively.

Shipping department of Pennsylvania Pump & Compressor Co. plant at Easton, Pa. At rear, a 14-in. centrifugal pump direct-connected to a 350-hp. motor, to be installed at Long Island Water Corp., Hewlett, L. I. Immediately in front of pump is a pair of 17 10x12, 2-stage duplex air compressors with 5-step clearance control for Metropolitan Water District of Southern California. This company is furnishing 12 of these units with 150-hp. synchronous motors for tunnel construction on new Colorado River aqueduct



New Bulletins

Oil Burners—The Engineer Co., 17 Battery Place, New York, N. Y. 12-page bulletin No. O-B-3-33 lists Enco burners, including high-capacity equipment.

Brewery Equipment—York Ice Machinery Corp., York, Pa. Bulletin File No. 32 on brewery equipment includes various refrigerating and cooling units.

Single-Groove Sheaves—American Pulley Co., Philadelphia, Pa. New bulletin on Single "A" Groove Sheaves and Single "B" Groove Sheaves, pulley sizes and corresponding belt sizes.

Automatic Regulators—Defender Automatic Regulator Co., 308 S. 8th St., St. Louis, Mo. Twenty-eight-page pocket catalog No. 13, full line of instruments and regulators. Bulletin E, new Model B electric control for mounting direct on pipe lines to operate chronometer valves.

Nickel Alloy Steel Compositions—International Nickel Co., Inc., 67 Wall St., New York, N. Y. Circular chart showing nickel-alloy steel compositions and treatments required to develop yield points up to 175,000 lb. per sq.in. Guide to selection of steels for bars, shafting and forgings.

Belt Trainers—Robins Conveying Belt Co., 15 Park Row, New York, N. Y. Four-page bulletin 85; belt trainers and lists other Robins products.

Water Heaters—Bell & Gossett Co., Chicago, Ill. Eight-page bulletin; B&G triple-duty domestic hot-water heater for all hot-water heating boilers.

Electric Heat—Verein Elektrowarme-Ausstellung Essen e.V., P. O. Box 346, Essen, Germany. Bulletin describes exposition of this organization.

Built-in Heaters—Commodore Heaters Corp., 11 W. 42nd St., New York, N. Y. Eight-page bulletin No. 6; Convectofin built-in heaters, new data and various types of installations.

Insulation—Mundet Cork Corp., 450 Seventh Ave., New York, N. Y. Sixteen-page Cork Pipe Covering Price Bulletin; includes engineering information on insulation, specifications and special installations.

Split-Phase Motors—Wagner Electric Corp., 6396 Plymouth Ave., St. Louis, Mo. Six-page bulletin; long-hour-duty split-phase motors.

Air-Conditioning Units—B. F. Sturtevant Co., Inc., Hyde Park, Boston, Mass. Eighteen-page catalog No. 392; air-conditioning units, applications, and lists company offices.

Instrument Transformers—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. 64-page catalog No. 45; technical information, ration and phase-angle curves.

Oil-Burning System—Bethlehem Steel Co., Bethlehem, Pa. 32-page catalog D-5; Bethlehem-Dahl mechanical atomizing oil-burning system for power plant and industrial uses; gives specifications.

Corrosion of Air-Conditioning Units—Ferro-Nil Corp., 500 Fifth Ave., New York, N. Y. Six-page folder; facts in regard to corrosion of air-conditioning equipment.

Stokers—Consolidated Car Heating Co., Inc., Albany, N. Y. Fifteen-page bulletin "Savings Worth Investigating," describing company's ram-type hydraulic underfeed stoker.

Heat Exchangers—Condenser Service & Engineering Co., Inc., Hoboken, N. J. Eleven-page bulletin; various units for heat exchange and associated services, and lists company offices.

Gravitometer—American Meter Co., Inc., 105 W. 40th St., New York, N. Y. Fifteen-page Bulletin E-21; company's metric gravitometer. Gives engineering information.

Flow Meters—Isometer Co., Elgin, Ill., Five-page folder, engineering data on Isometer straight-line flow meter which uses straight-line flow through variable orifice with fixed differential.

Diesel-powered Refrigeration — Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo. Twelve-page bulletin, "Lower Power Costs for Ice and Refrigeration with Diesels," typical Busch-Sulzer installations and gives indication of possible savings.

Unit Coolers—Buffalo Forge Co., Buffalo, N. Y. Four-page bulletin No. 2904; engineering data on unit coolers.

Portable Diesels—Superior Engine Co., Springfield, Ohio. Four-page bulletin No. 126; new Superior portable diesel power unit with radiator cooling, 65 to 215 hp.

New Plant Construction

McGraw-Hill Business News Department Is Prepared to Furnish a More Complete Daily Service

Ariz., Douglas—City plans building municipal power and light plant. $700,000. G. G. Childs, city engr.

Calif., San Francisco—City and County of San Francisco to seek funds under National Industrial Recovery Act for cold storage plant. $150,000.

Ill., Chicago—Sept. 7, by U. S. Eng., 1st Chicago Dist., 333 North Michigan Ave., constructing Dresden Island and Starved Rock steam and compressed air plants on ice chute piers of respective dams, incl. 2 concrete boiler houses, compressed air plant, reciprocating water pump, piping, electrical equipment and appurtenant work. Former bids rejected.

Ill., O'Fallon — City Council approved preliminary estimates by W. A. Fuller Co., 2916 Shenandoah Ave., St. Louis, Mo., for equipping a municipal light and power plant. Est. $123,-200 with diesel engines; $143,200 with steam unit burning coal.

Ill., Springfield—City made plans 95x138 ft. power plant, 105 ft. high. $175,000. Applied for Federal aid. Will also purchase equipment. Burns & McDonnell Eng. Co., 107 West Linwood Blvd., Kansas City, Mo., engrs.

Ia., Morning Sun—Voted $70,000, to construct municipal electric plant.

Ia., Wapello—Voted to construct municipal light plant. H. L. Cory Co., 1033 Redick Tower, Omaha, Neb., engrs.

Ia., Wellman—Voted to construct municipal light plant. H. L. Cory Co., 1033 Redick Tower, Omaha, Neb., engrs.

Ia., Winfield—Voted to construct municipal electric plant. $70,000.

Kan., Washington—City, A. N. Holloway, mayor, election Sept. 12, $88,000, for municipal light and power plant. E. T. Archer & Co., 609 New England Bldg., Kansas City, Mo., engrs.

La., Hammond — Fourth Jefferson Drainage Dist., Jefferson Parish, retained Henry A. Mentz & Co., Inc., to draw plans and specifications for reconstructing pumping stations. Plan application to Government for $250,000 loan.

Mich., Adrian—City making surveys, preliminary plans and estimates for brick, steel, concrete municipal electric light plant with steam driven generating equipment. W. Frazier, city engr.

Mich., Grayling—Village, E. L. Sparkes, clk., plans and estimates to be prepared for waterworks, incl. pumps, mains and equipment. To exceed $15,000. Plans petition for Federal aid in financing same.

Mich., Milan—U. S. Eng., plans altering and constructing power plant additions at U. S. Prison, here. $32,500. Smith, Hinchman & Grylls, Marquette Bldg., Detroit, archts.

Mich., Port Hope—Village plans and estimates to be prepared for waterworks system, incl. purifying equipment, pumping station, 2 mi. c.i. watermains, $17,500. Petition to be filed with Federal aid in financing under National Industrial Recovery Act.

Minn., Mountain Lake—Bids Sept. 6, by Village, I. D. Bargen, clk., municipal electric power plant and distribution system, incl. power house and equipment. $40,000. G. M. Orr & Co., Baker Bldg., Minneapolis, engrs.

Minn., St. Cloud—City plans municipal power plant. Burns & McDonnell Eng. Co., 107 Linwood Blvd., Kansas City, Mo., engrs.

Mo., Caruthersville—City preliminary surveys completed municipal light plant. $225,000. Will vote on bonds soon. Burns & McDonnell Eng. Co., 107 West Linwood Blvd., Kansas City, engrs.

Mo., Doniphan—City retained W. A. Fuller Co., engrs., 2916 Shenandoah Ave., St. Louis, to design municipal light and power plant addition. $60,000.

Mo., Kennett—City plans diesel engine power plant and distribution system. $140,000. Burns & McDonnell Eng. Co., 107 Linwood Blvd., Kansas City, engrs.

Mo., Marseilles—Bids Sept. 18, by U. S. Eng., 333 North Chicago Ave,. Chicago, Ill., constructing Marseilles steam and compressed air plant, north bank Illinois River, here, incl. brick boiler house, heating, plumbing, well and pump, steam plant, compressed air plant, piping and appurtenant work.

Mo., Monroe City—City sketches light plant improvements. $40,000. W. B. Rollins & Co., 339 Railway Exch. Bldg., Kansas City, engrs.

Mo., Wentzville—City preliminary plans deep well pumps, tank on tower, 2- to 8-in. c.i. mains, hydrants, etc. $40,000. Russell & Axon, 229 Roosevelt Bldg., St. Louis, engrs.

N. J., Bordentown—Municipality plans electric power plant. $75,000. C. Rodgers, Bordentown, consult. engr.

N. J., Clinton—Bids Sept. 7, by State Dpt. Institutions & Agencies, State Office Bldg., Trenton, 1 story, basement, brick, rein.-con. power plant, at New Jersey State Reformatory for Women. $40,000. C. N. Leathem, State Office Bldg., engr. and archt.

N. Y., Willard—Bids Sept. 13, by Commissioner Dpt. Mental Hygiene, State Office Bldg., Albany, constructing, heating, sanitary, and electrical work for power plant addition and service connections at Willard State Hospital.

O., Cleveland—City, T. M. Carey, dir. P. Utilities, survey completed and legislation underway to place on ballot for voters approval on Nov. 7, for additions and alterations to municipal power plant. $2,000,000. R. Hoffman, city engr.

Ore., North Bend—Mountain States Power Co., North Bend, plans repairing electric power plant, $40,000.

Pa., Bradford — City plans electric power plant. $1,000,000. Await approval of City Council. Will ask loan under National Industrial Recovery Act. R. Husselman, Hipp Bldg., Cleveland, O., engr.

Tex., Wichita Falls—City, c/o V. R. Smitham, mgr., construct 1st unit of municipal power plant, incl. power unit with considerable new transmission lines. Est. $350,000, ultimate cost $2,310,000. Montgomery & Ward, Harvey-Snider Bldg., Wichita Falls, engrs.

Va., Covington—City, J. S. Methers, mgr., having complete surveys and estimates made by Wiley & Wiley, consult. engrs., Lynchburg, for municipal power plant.

Utah, Orderville — Kane County Power Co., plans hydro-electric plant to furnish power and light to Orderville, Mt. Carmel, Glendale and Alton. $44,000. J. H. Clark, Panguitch, engr.

Washington—DAM—Columbia Basin Comn., J. O. Sullivan, secy., Civic Bldg., Spokane, taking bids Sept. 1 for 22 core drilling and test pits, for dam site, for Grand Coulee Project on Columbia River. Public Wks. Administration, Washington, allotted $63,000,000 for project, $4,000,000 to be spent remainder of year for constructing branch railroad, highway and on surveys. Field headquarters will be established at Almira about 22 mi. south of dam.

Wis., Madison—Oscar & Mayer & Co., A Roth, vice pres., North St., making plans 1 story, basement, 45x60 ft., boiler plant. C. H. Kane Eng. Co., Chicago, Ill., engrs.

Wis., Marion—City, J. W. Buhr, clk., plans waterworks system, incl. plant equipment, pumps, mains, $20,000. Engineer not appointed.

Wis., Two Rivers—City, E. J. Donnelly, mgr., plans municipal light and power plant. $240,-000. Burns & McDonnell Eng. Co., 107 West Linwood Blvd., engrs. Applied for loan under National Industrial Recovery Act.

Equipment Wanted

GENERATING PLANT—**Burlingame, Calif.**—City making surveys electric distributing system, incl. Diesel electric generating plant. $715,000.

INTAKE SCREEN, etc.—**Wash., D. C.**—Bids Sept. 14, at office D. Lynn, architect of Capitol, mechanical traveling clear water intake screen and accessories, reticulated steel walks, wood piles, at U. S. Capitol Power Plant Pump House.

TURBINES—**Boulder City, Nev.**—Bids Sept. 12, by Bureau Reclamation, Dpt. Interior, Denver, Colo., two 3,500 hp. horizontal shaft, double overhung, impulse type hydraulic turbines, complete with hydraulically-operated follower ring type shut-off valves, 2 oil pressure governors complete with pumping equipment and auxiliary equipment for regulating speed of above turbines and two 3,000 kva. 300 r.p.m. 3 phase 60 cycle, 2400 volt, altering current generators, complete with direct connected main exciters and pilot exciters for installing at Boulder Power Plant, Boulder Canyon project, Arizona-California-Nevada. E. Mead, comr.

PUMPING EQUIPMENT—**Tacoma, Wash.**—City, election Sept. 26, $3,000,000, for sewerage system, incl. 180,695 ft. 10- to 96-in. pipe, pumping plant including electric pumping equipment etc. To apply for Federal loan. C. Forsbeck, city engr.

TRANSFORMERS—**Wellington, New Zealand**—Bids Oct. 24, by Secretary P. Wks. & Tenders Com., four 3,333 kva. transformers, incl. relays and spares.